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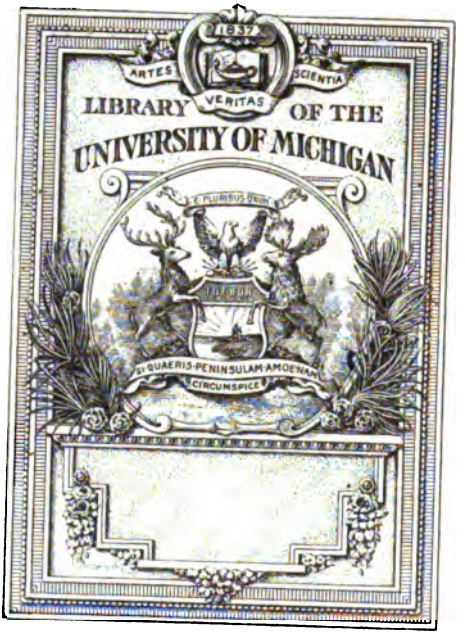

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WILLIAM PETIT TROWBRIDGE.

Died August 12, 1892.

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THE

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VOL. XIV. NOVEMBER, 1892. No. 1.

In Memoriam.

WILLIAM PETIT TROWBRIDGE.

BY F. R. HUTTON, C.E., PH.D.

PROFESSOR WILLIAM P. TROWBRIDGE was at the head of the Department of Engineering in the School of Mines of Columbia College from May 1877 till his sudden death on August 12, 1892.

He was born at "Strawberry Hill," near Birmingham, Oakland Co., Michigan, May 25, 1828. He was therefore sixty-four years old at the time of his death. At the age of sixteen he was appointed a cadet in the United States Military Academy at West Point in an entering class of eighty-five, whence he graduated in 1848 at the head of his class. During his last year at the Academy when only nineteen years old he acted as Assistant Professor of Chemistry, the exigencies of the field service in the Mexican War calling for the attendance there of all available graduates. He entered the Engineer Corps by virtue of his standing, with the rank of second lieutenant, and was ordered back to his Academy as assistant in the Astronomical Observatory under Prof. Bartlett of the Department of Philosophy, serving for two years till 1850. This experience fitted him for duty on the work of the United States Coast Survey, to which at his own request he was subsequently ordered. Here he was assistant to Professor A. D. Bache

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working upon the primary triangulation of the coast of Maine, which in 1852 was placed in his charge. The period from 1851 to 1856 was entirely devoted to survey work, partly along the Appomattox River below Petersburg and the James River below Richmond in Virginia, and partly along the Pacific slope. The work upon the rivers was principally with a view to the improvement of their navigation, and he pointed out the advantage of the cut-off at Farrar's Island, which was actually carried out during the Civil War by the army, and was then and has been since known as the Dutch Gap Canal, shortening the distance for vessels by seven miles. The work on the Pacific slope (1853–6) was tidal and magnetic as well as geodetic, and covered the space between San Diego and Puget Sound, a length of over 1300 miles. The tidal gauges established by Lieut. Trowbridge recorded the earthquake waves emanating from Simoda, Japan, Dec. 23, 1854, while information of the occurrence reached this country *via* India two months after the probable nature of the disturbance had been reported. The waves had a length of 210 miles and travelled 355 miles per hour. He was engaged at this work for three years and often spoke of the pleasant memories which he retained of those then remote districts.

In 1856 he resigned his first lieutenancy (won in 1854) to accept the chair of Mathematics in the University of Michigan, remaining only a year, however, to return by the solicitation of Professor Bache to the Coast Survey to act as his permanent scientific secretary, and to reside in Washington, D. C. He held this office from 1857 to 1862. During this period he devoted himself to preparing for publication the results of the exploration of the Gulf stream; in 1860 he went to Key West to establish a permanent observatory for the automatic registration of magnetic variations (the first in this country); in 1861, at the breaking out of the war, he was summoned by his old chief, Gen. Totten, as a civilian, to loyal service anew, being assigned the duty of preparing minute descriptions of the harbors, inlets, and rivers of the Southern coast from Delaware Bay to Galveston, and in 1862 the hydrographic survey of Narragansett Bay, R. I., was entrusted to him to determine its suitability as a Navy Yard Station. The survey resulted in the abandonment of the project.

During the remainder of the war, he had charge of the branch office of the War Department in New York City, acting as agent

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in the supply of material for use in the field, and as constructor of local fortification. This was a heavy responsibility in its financial relations to contractors supplying war material, involving an aggregate of several millions of dollars, and exacted the most scrupulous honesty and integrity for its faithful discharge, and in the duty of the construction of forts some difficulties had to be overcome. The principal works were the fort at Willett's Point and on Governor's Island and the repairs of Fort Schuyler. The Willett's Point fort was to be the largest seacoast battery on the Atlantic, and was to carry 100 13-inch guns in three tiers of casemates and in barbette. Of the masterly manner in which the first-mentioned of these works was executed General H. L. Abbot, the officer for many years in command of the fort, spoke as follows: "The work was done in great haste, to close the harbor of New York against raids from war-vessels of the Confederacy, or of their possible foreign allies. The site presented peculiar difficulties, requiring a coffer-dam and an unusual system of sub-drainage to preserve the foundations. A steep bluff in the rear contracted the space and greatly increased the difficulty of handling the materials. A wharf over 450 feet long had to be built, with all the needful shops and buildings. By special devices, showing much skill and ingenuity Professor Trowbridge overcame these difficulties, and not only made astonishing progress with the work, but left it one of the finest specimens of granite masonry to be seen in any of our fortifications."

After the close of the war in 1865, Professor Trowbridge became the Vice-President of the Novelty Iron Works in this city, of which Mr. Horatio Allen was the President. He remained in this relation till 1871, and it was during this period that he became so well and favorably known as a mechanical engineer. Mr. Allen had been the first generally to introduce the locomotive engine from England in 1829, and had himself run the first imported engine for the Delaware and Hudson Canal Company. He had designed the early American locomotives run in South Carolina, and the Novelty Works had designed and constructed the first transatlantic steamers, of the Collins Line. During the war, in common with the rest of the marine shops, there had been abundant business in construction and alteration of vessels and machinery. It was during Professor Trowbridge's connection with the Novelty Iron Works that those experiments were undertaken

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to determine the consumption of water for horse-power in engines at different points of cut-off of the stroke of the cylinder, which have become historic, and have served as starting point and standard for much of the more recent work in this direction. They also pointed out the advantages which would follow from the use of a higher speed of piston in the engine than had been usual in the designs up to that time. These experiments led the practice of many engine builders for years, until the rise of the type which electric lighting practice has called into use. But the business changes following the lessened amount of marine activity in construction after the war induced the closure of the works, and the disposal of its tools and patterns and drawings. Many of these latter illustrating the practice of the Pacific Mail Steamship engineers for many years, Professor Trowbridge was able to secure for the Sheffield-Scientific School of Yale College to which he was called by the corporation in 1871 as the professor of dynamic engineering. He was very active in the building up of his new department, and in the planning and construction of the New Sheffield Hall, in which the engineering instruction was given. He remained in this field until in May, 1877, he was called by the Trustees of the College to the position he held till his death.

It will be recalled by the earlier graduates of the School of Mines that the professorship of Civil and Mining Engineering had been filled from the beginning of the history of the School until this date by a very able mathematician and an ex-army officer who had received his education both at West Point and at the Ecole des Mines at Paris. But with all his attainments and ability there had been a growing dissatisfaction with his methods, which had found a culminating expression at a meeting of the Alumni held in the winter of 1876–77, and which was followed in April of that year by the presentation of a printed report by a committee of the Trustees, definitely abolishing the former chair and establishing the new chair of engineering, and an adjunct professorship of practical mining and an instructorship in mechanical engineering. When the election was held in May, Professor Trowbridge was chosen to the new chair, and the other positions were filled by Professor H. S. Monroe and the writer respectively. The department was immediately reorganized on the new basis when the new officers began their duties in the autumn of that year, and the history of the department from that time has been the history of

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its chief. There was added to the courses as they existed in 1877, successively courses in thermo-dynamics, dynamics of machinery, and water-supply engineering, while the existing courses in hydraulics, braced structures, machines and motors were developed, sub-divided, and built upon out of all resemblance to their old standards as the succeeding generations of classes made possible the elevation of requirement. Under the progressive planning of Professor Trowbridge, the old area of the third floor of the Fiftieth Street building was successively outgrown, first from 1879 to 1883 to fill as additional space the second floor of the old college building, and later the new floor for engineering in the Fourth Avenue building was added and for the last few years even this space was too cramped for efficient work. When he came, the school gave only the degrees of mining engineer and civil engineer, and the latter was regarded as subsidiary.

During the early years of his incumbency, the members taking this course began largely to increase, and, later, courses for the degree of Sanitary Engineer and Electrical Engineer were added to the list of engineering degrees; and had there been room in the restricted site of the School of Mines, mechanical engineering, which had his warm support, would have had also a place. He was made a member of the University Council of the College when the new organization was effected, in 1891, and was a favorite choice upon important committee labor, where his sound judgment and judicious counsel made him a most valuable member. He also gave much careful thought to the subject of training of graduates in engineering for further and higher competency. There were long and frequent conferences with the writer upon a plan very dear to his heart, of organizing a special department for higher specialization, which should be equipped with professional apparatus and machinery, and in which the instruction should be given by distinguished specialist practitioners. This plan reached the stage of an official letter to President Barnard of the College, and later to President Low, but has had to rest in abeyance to make room for more urgent matters.

Of Professor Trowbridge's work as a teacher of undergraduates, it is difficult to speak without at the same time considering his traits as a man. A more unselfish and self-sacrificing person is rarely met, and this would appear to be the keynote of that success which was accorded to him, and which has made so strong a

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bond between him and so many of his old students. He was genial and familiar, and yet never undignified in his intercourse with them, and each felt that he could rely upon an affectionate personal interest if he wanted advice or help. The instructor who can thus command the affectionate respect of a class of young men of professional school age, finds an easy path of influence before him. There are many who feel that in the death of their former professor they have lost a firm and wise friend and counsellor.

In his relations as head of a large and important department of instruction, those who have been thus associated with him have only words of praise and affection. The position was a difficult and delicate one as concerned subordinate officers, but in every way he showed himself most considerate and without self-seeking narrowness.

He was married April 21, 1857, at Savannah, Ga., to Miss Lucy Parkman, one of the three surviving members of a large family which was lost in the steamer *Pulaski* in 1838. Of this marriage there were eight children. His wife, three sons and three daughters survive him. In his relations to his family as husband and father, those who have known them in intimacy will recall how he was the centre around whom the family circle grouped itself, and who was their prime dependence. His loss there is one from which the stranger pen must refrain to allude.

Prof. Trowbridge's two best known recent professional achievements were his design for the first cantilever bridge and his coil boiler. It was while he was at the Novelty Iron Works that he designed a cantilever bridge for the East River at Blackwell's Island, and urged the adoption of the cantilever system as the most available for spans beyond the practical limit of the single girder. A company was formed in 1869–70, of which Mr. Wm. Steinway was president, for the erection of the bridge according to the proposed plan; but the value of the cantilever system, so strongly urged then by Mr. Trowbridge, and so signally successful since that time in other places—as at Niagara Falls and at the Firth of Forth—was not publicly appreciated, and the panic of 1873 put an end for the time to all efforts to build the bridge. His coil boiler was thought out while he was at the Sheffield Scientific School, and was designed to incorporate the most advanced ideas of forced circulation of the water, automatic supply of feed-

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water from a magazine, and the self-feeding of its fuel. Exhaustive experiments and trials were kept up to develop the weak places in the design, and most satisfactory results were obtained as to the capacity of the boiler in small bulk and the reliability of the subsidiary apparatus. Its manufacture was turned over to a company, and the inventor was unable to pursue the matter further. Prof. Trowbridge had also given much thought to apparatus for deep-sea sounding, and felt very sanguine as to the applicability of electric devices for this object.

During his connection with the School of Mines, Professor Trowbridge retained his family residence in New Haven, where he remained only from Friday night to Monday morning early during the college terms. This plan gave him the freedom from all college calls when at home, and released him from demands from the home circle when in New York. He was a member of the Century Club, but spent much of his time in his study when the College did not call him there. But his Connecticut residence brought him many engagements. He was Adjutant-General of Connecticut from 1872 to 1876, under Gov. Ingersoll; from 1873 to 1878, Commissioner for building the Capitol at Hartford; from 1870 to 1876, Commissioner for building a bridge across the Quinnipiac River; from 1872 to 1878, Commissioner for establishing harbor lines at New Haven. He was also appointed by Gov. Cornell, of New York, one of three commissioners to examine the State Capitol at Albany, the other two being Mr. Geo. B. Post, the architect, and Prof. Babcock, of Cornell University.

He was author of *Heat and Heat-Engines* (1874); but on the exhaustion of the edition he had been too busy with his teaching-work to undertake its re-issue, and was engaged on this work when his hand was stilled by death. He had planned a series of four, which were to have been Heat, Light, Magnetism and Electricity as manifestations of energy. He was associate-editor with Dr. Barnard of *Johnson's Encyclopædia*, and wrote also for other standard publications. His college honors were an A.M. from Rochester University in 1856, and from Yale in 1870; Ph.D. from Princeton in 1880; and LL.D. from Trinity in 1883, and Michigan University in 1887. In 1880, under the broad plans of General Francis A. Walker for the Tenth Census, Professor Trowbridge was put at the head of the Department of Power and Machinery employed in Manufactures, and several notable monographs were issued in this subdivision under his solicitation and control.

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Professor Trowbridge was a member of the National Academy of Sciences, and presided at its sessions of 1882. He was a Vice-President of the American Society of Mechanical Engineers, and member of the other engineering societies at one time or another. He was very active in the New York Academy of Sciences, and a frequent contributor and occasional lecturer before it, and there were many other organizations which claimed a share of his broad-minded interest.

In fine, the School of Mines has had in Professor Trowbridge that rare combination of personal qualities of character with intellectual capacity and technical acquirement, which made him an almost ideal selection for the position which he was called upon to fill. With ability to appear before a broader public with credit, and appreciating the advantages which follow to an institution from such wider recognition of its professors, yet withal so modest and conscientious as never to be tempted to neglect a near duty because inconspicuous, his loss is made the more grievous by the very rarity of the union of these qualities in one person. The School of Mines has been privileged so long to rejoice in the relations which have now been ended by his death.

THE CLASSIFICATION OF ORE DEPOSITS.

By J. F. KEMP.

In the classification of ore deposits the same systematic arrangement is not to be expected, as in the grouping of plants, animals, or minerals. Ore deposits have not the underlying affinities and relationships of living organisms or of definite chemical compounds. The series of objects is too diverse and, in the nature of the case, the standards of appeal must be different. The subject is, however, one of great practical importance as well as of great scientific interest. A vocabulary of intelligible terms is indispensable for description and comparison, and, under our mining laws, often for valid titles, while as a vehicle for the spread of knowledge and reasonable conceptions regarding these phenomena, its importance cannot be overestimated.

All schemes of classification rest on these principles: form, ori-

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gin or the genetic principle, (including method, relative time of origin as contrasted with the walls, etc.), state of aggregation, and mineral contents. Of these, the principle of form is usually esteemed the weightiest, and is given the greatest prominence, partly because it has been thought to be the one most closely affecting exploitation, and partly because it involves less that is or has been, up to very recent times, more or less hypothetical. Yet form is largely fortuitous, and it has, of course, no law, while, with sufficient knowledge, the genetic principle is the one giving a far more thoroughly scientific basis. Every one, in opening up or searching for an ore body, must be influenced by some hypothesis, either of shape or origin. It is the conviction of the writer that, with all our deficiencies of knowledge, the genetic principle is also the best guide, even in practical development.

Very early in the development of mining literature the distinction was made between those ore bodies which are parallel to the stratification, and those which break unconformably across it. This took place long before the epoch-making time of Werner, and even before the conception of the relative ages of strata had been at all generally grasped. Thus among the Germans we find the terms "Lager" and "Flötze"* on the one side, being set off in contrast to "Gang" (vein) on the other. Werner, writing in 1791, quotes Von Oppel's distinctions between Flötze (strata, beds) and Gänge (veins), which were published in 1749, but without doubt, as mining terms, they go much further back. Beyond this

* Lager and Flötze are difficult to render into English and retain their native shades of meaning. The later writers in Germany, (Serlo, Gätzschmann, v. Groddeck, Köhler), define them as being interbedded bodies, each later than the footwall in formation, and older than the hanging; and that Lager are much more limited in horizontal extent than Flötze. R. Wabner shows, however, in the *Berg. u. Huet. Zeitung*, Jan. 2, 1891, p. 1, that writers in the earlier part of the century did not entirely restrict the term Lager as regards age relative to the foot and hanging, but applied it to ore bodies, which follow the general bedding, although they may have been introduced much later than the formation of the walls. Thus the frequent occurrence of lead ores in limestone, along certain beds (southeast Missouri, for example), would be called Lager. We would apply the terms impregnation, or dissemination, or bed-vein, to such. Flötz we would call stratum, and Lager, as defined by the later authors, "bed" or "seam." Werner, for instance, in his classification of the rock formations of the globe, made, I. Urgebirge (Primitive, Primary, etc., having no fossils). II. Secondary, subdivided into, A. Ueberganggebirge (Transition, more or less metamorphosed sediments, but fossiliferous). B. Flötzgebirge (Unaltered strata). From this the meaning of Flötz can be grasped. By contrast, a magnetite lense is a good illustration of Lager.

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simple indication of the views of the older writers, no attempt will be here made to quote authorities earlier than 1850. This is justifiable because the important works, like De la Beche's *Geology of Cornwall and Devon*, and Henwood's *Metalliferous Deposits of Cornwall and Devon* are rather discussions of veins than systematic attempts at classification.

In the following pages the principal schemes of classification are grouped according to certain relationships and similarities that run through them. It would be interesting to arrange them in chronological order, but points of likeness and unlikeness would not be thus brought out, nor can the influence of one writer on another be so clearly manifested. The underlying object of the paper, aside from showing in a birds-eye view what has been done, is to lead up to an attempt at a purely genetic classification, from which mere form is eliminated to the last degree, and well-recognized geological phenomena are brought to the foreground.

It has, indeed, been said with force, that the origin of ore deposits is a subject which is very largely a matter of hypothesis, and that it involves profound subterranean causes, of which we know but little. Still, it is held in this paper that an acquaintance with what has been accomplished in recent years by our best workers, and a rigid adherence to well-recognized principles in geology and mineralogy, especially as developed in rock study (*i.e.*, in that department of geology that, of late years, we have grown to call petrography), will establish much that cannot be questioned, and will aid in differentiating the cases which are still objects of reasonable doubt. It is, however, true, that among the subjects on which human imagination, often superstitious, has run to wild extremes, and on which cranky dreamers have exercised their wits, the origin of ore deposits stands out in particularly strong relief.

A. *Schemes Involving only the Classification of Veins.*

(1).

G. A. v. Weissenbach,* (Gangstudien, 1850, p. 12).

(*a.*) Sedimentärgänge (Sedimentary Veins).

(*b.*) Kontritionsgänge (Attrition Veins).

(*c.*) Stalactitische oder Infiltrationsgänge (Stalactitic or Infiltration Veins).

* See also Whitney's *Metallic Wealth, U. S.*, p. 44, 1854.

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(*d.*) Plutonische oder Gebirgsmassengänge (Masses, dikes, knobs, bosses, etc., not necessarily with ores).
(*e.*) Ausscheidungsgänge (Segregated Veins).
(*f.*) Erzgänge (True or Fissure Veins).

(2).

B. v. Cotta, in comments on v. Weissenbach's Scheme. Gangstudien, 1850, p. 79. According to the Vein Filling.

1. Gesteinsgänge (Dikes).
   (*a.*) Not crystalline (Sandstone.)
   (*b.*) Crystalline (Granite).
2. Mineralgänge (Veins).
   (*a.*) Of one non-metallic mineral.
   (*b.*) Of several non-metallic minerals.
3. Erzgänge. Ore veins.

(3).

B. von Cotta, *idem.*, p. 80. According to Shape and Position.

I. Wahre, einfache Spaltengänge (Fissures).
   (*a.*) Quer durchsetzende, Cross fissures.
   (*b.*) Lagergänge, Bed veins.
   (*c.*) Klüfte (Cracks), Adern (Veinlets).
II. Gangzüge (Linked veins).*
III. Netzgänge (Reticulated Veins).
IV. Contaktgänge (Contact Veins).
V. Lenticulargänge (Lenses).
VI. Stockförmige Gänge (Stocks, Masses).

(4).

B. v. Cotta, *idem*, p. 80. According to the texture of the vein filling.

I. Dichte Gange (Compact Veins).
II. Krystallinische Gänge.
III. Krystallinisch, körnige (granular) Gänge.
IV. Krystallinisch, massige Gange.

* Gangzug is happily translated "linked veins," by Mr. G. F. Becker (*Quicksilver Deposits*, p. 410.) Any attempt to render the original by preserving the figure of a flock of birds or school of fish, etc., is as Mr. Becker remarks, infelicitous, if not impossible.

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V. Gänge mit Lagentextur (Banded veins).
  (*a.*) Ohne Symmetrie der Lagen (unsymmetrical).
  (*b.*) Mit Symmetrie der Lagen (symmetrical).
VI. Gänge mit Breccien oder Conglomerattextur.

(5).

J. Leconte, A. J. S., July, 1883, p. 17.
1. Fissure Veins.
2. Incipient Fissures, or Irregular Veins.
3. Brecciated Veins.
4. Substitution Veins.
5. Contact Veins.
6. Irregular Ore Deposits.

In v. Weissenbach's table, the sedimentary veins are much the same as the "sandstone dikes," which J. S. Diller has recently described. (*Bull. Geol. Soc. Amer.*, I., 411.) They and the stalactitic veins have small practical value, although of great scientific interest. Under (*d*), the stock-works with tin ores are the principal illustration of economic prominence. The attrition veins are an important class, and increasing study has widened the application of this or synonymous terms. Segregated veins and true veins are well-known forms. In the comments of v. Cotta, which follow v. Weissenbach's paper, veins are grouped from every possible standpoint, v. Weissenbach's scheme being taken as the one based on origin. Nos. 2 and 4 have small claims to attention. No. 3 foreshadows the drift of many subsequent writers. The meanings of the terms are self-evident, except perhaps Gangzug (linked veins.) This refers to a group of parallel, and more or less over-lapping veins, deposited along a series of openings, evidently of common origin. It is a convenient term.

The terms used by Leconte may be passed without comment as being self evident in their meaning, except (4) and (6.) The scheme was devised, as a perusal of the citation will show, after the distinguished author had set forth some original views of the causes which lead to the precipitation of ores, and had forcibly stated others very generally accepted. In the explanatory text some quite curious associations are found, which are cited by way of illustration. Thus under group (4), stalactites, caves, gash veins and the Leadville ore bodies are considered examples, and

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under group (6) the lumping together of beds, igneous masses and all other forms of so-called irregular deposit is decidedly open to criticism. This is the more emphatic, because the concluding sentences of the paper (of whose general value and excellence there can be no question), give the impression that the author felt he had cleared up all the points in the origin of ore bodies which would be of interest or importance to a purely scientific investigator as contrasted with a practical miner.

B. *General Schemes Based on Form.*

(6).

Von Cotta and Prime. Ore Deposits, N. Y., 1870.

I. Regular Deposits.
- A. Beds.
- B. Veins.
  - (*a.*) True (Fissure) Veins.
  - (*b.*) Bedded Veins.
  - (*c.*) Contact Veins.
  - (*d.*) Lenticular Veins.

II. Irregular Deposits.
- C. Segregations.
  - (*a.*) Recumbent.
  - (*b.*) Vertical.
- D. Impregnations (Disseminations).

(7).

Lottner-Serlo. Leitfaden zur Bergbaukunde, 1869.

I. Eingelagerte Lagerstätten (Enclosed Deposits).
- A. Plattenförmige (Tabular).
  - (*a.*) Gänge (Veins).
  - (*b.*) Flötze und Lager (strata, beds, seams).
- B. Massige Lagerstätten (Massive Deposits).
  - (*a.*) Stöcke. } Masses.
  - (*b.*) Stockwerke. }
- C. Andere unregelmässige Lagerstätten (other irregular deposits).
  - (*a.*) Nester (Pockets).
  - (*b.*) Putzen.
  - (*c.*) Nieren. (Kidneys.)

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II. Aufgelagerte Lagerstätten (Superficial Deposits).
D. Trümmerlagerstätten (Placers).
E. Oberflächliche Lager (Surface beds).

(8).

Koehler. Lehrbuch der Bergbaukunde, 1887.
I. Plattenförmige Lagerstätten (Tabular Deposits).
(*a.*) Gänge (Veins).
(*b.*) Flötze und Lager (Strata, beds, seams).
II. Lagerstätten von unregelmassige Form (Deposits of irregular Form).
(*a.*) Stöcke und Stockwerke (Masses).
(*b.*) Butzen, Nester und Nieren (Pockets, concretions, etc.).

(9).

Callon. (Foster and Galloway's Translation), Lectures on Mining, 1876.
I. Veins.
II. Beds.
III. Masses (*i.e.*, not relatively long, broad and thin).

The scheme of v. Cotta and Prince carries out the principle of form to its logical and somewhat trivial conclusion. Thus under irregular deposits, it is a matter of extremely small classificatory moment, whether an ore body is recumbent or vertical. Otherwise the scheme is excellent, and its influence can be traced through most of those that are of later date. The original draft came out in the German in 1859. All the others are from treatises on mining, in which this subject plays a minor rôle, and indicates the tendency referred to above, of the mining engineers, when writing theoretically to imagine certain fairly definite forms, which are to be exploited. As previously remarked, however, considering the uncertainty of ore bodies and their variability in shape, it is here argued, that the genetic principle might better take precedence. Several of the German terms are difficult to render into English mining idioms, as for example, Stock, Butzen (Putzen), Nester and Nieren.

C. *Schemes, Partly Based on Form, Partly on Origin.*

(10).

J. D. Whitney, *Metallic Wealth*, 1854.
I. Superficial.

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II. Stratified.
  (*a.*) Constituting the mass of a bed or stratified deposit.
  (*b.*) Disseminated through sedimentary beds.
  (*c.*) Originally deposited from aqueous solution, but since metamorphosed.

III. Unstratified.
  A. Irregular.
    (*a.*) Masses of eruptive origin.
    (*b.*) Disseminated in eruptive rocks.
    (*c.*) Stock work deposits.
    (*d.*) Contact deposits.
    (*e.*) Fahlbands.
  B. Regular.
    (*f.*) Segregated veins.
    (*g.*) Gash veins.
    (*h.*) True or fissure veins.

(11).

J. S. Newberry, SCHOOL OF MINES QUARTERLY, March, 1880, May, 1884.

I. Superficial.

II. Stratified.
  (*a.*) Forming entire strata.
  (*b.*) Disseminated through strata.
  (*c.*) Segregated from strata.

III. Unstratified.
  (*a.*) Eruptive masses.
  (*b.*) Disseminated through eruptive rock.
  (*c.*) Contact deposits.
  (*d.*) Stockworks.
  (*e.*) Fahlbands.
  (*f.*) Impregnations.
  (*g.*) Chambers.
  (*h.*) Mineral veins.
    1. Gash veins.
    2. Segregated veins.
    3. Bedded veins.
    4. Fissure veins.

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(12).

J. A. Phillips, Ore Deposits, 1884.

I. Superficial.
  (*a.*) By mechanical action of water.
  (*b.*) By chemical action.

II. Stratified.
  (*a.*) Deposits constituting the bulk of metalliferous beds formed by precipitation from aqueous solution.
  (*b.*) Beds originally deposited from solution but subsequently altered by metamorphism.
  (*c.*) Ores disseminated through sedimentary beds, in which they have been chemically deposited.

III. Unstratified.
  (*a.*) True veins.
  (*b.*) Segregated veins.
  (*c.*) Gash veins.
  (*d.*) Impregnations.
  (*e.*) Stockworks.
  (*f.*) Fahlbands.
  (*g.*) Contact deposits.
  (*h.*) Chambers or pockets.

It is at once apparent that Whitney's scheme contains the essentials of the others, which are merely slight modifications. Newberry introduces impregnations, chambers and bedded veins. The first-named is a useful term, although it is not always easy to distinguish impregnations from others earlier given. Thus, they may be very like the division, disseminated through strata, or disseminated through eruptive rock, or if in metamorphic rock, fahlbands. The word is also used to indicate places along a vein where the ore has spread into the walls. The term chambers or caves has found application in the west, and is a useful addition. Bedded veins appear also in v. Cotta above (No. 6). Phillips seeks to explain the methods of origin in his use of Whitney's scheme and clearly feels the importance of emphasizing the genetic principle more strongly. Much of it is implied in the simpler phraseology, however, and the extended sentences lack the incisiveness of the earlier schemes. The arrangement as set forth by Whitney is worthy of high praise, and the scheme is one of the many valuable

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things in a book that has played a large part in the economic history of the United States.

D. *Schemes Largely Based on Origin.*

(13).

J. Grimm, *Lagerstätten*, 1869.

I. Gemengtheile oder grössere Einschlüsse in den Gebirgsgesteinen. Einsprengung, Imprägnation. (Essential component minerals and inclusions in country rock. Impregnations).

(*a.*) Ursprüngliche Einsprengung. (Original with the enclosing rock).

(*b.*) Von anderen Lagerstätten weggeführte Bruchtheile, etc. (Fragments brought from a distance. Placers, ore-bearing boulders. Breccias).

II. Untergeordnete Gebirgsglieder oder besondere Lagerstätten. (Subordinate terranes or special forms of Deposits).

(*a.*) Plattenförmige Massen. (Tabular masses).

1. Lager oder Flötze. Bodensatzbildung. (Beds, strata).
2. Gänge, Klüfte, Gangtrümmer, etc. (Veins of varying sizes).
3. Plattenförmige Erz-ausscheidungen und Anhäufungen. (Segregated veins).

(*b.*) Stöcke und regellos gestaltete Massen. (Stocks and irregular masses).

1. Lagerstöcke Linsenstöcke, Linsen. (Lenticular deposits, etc.).
2. Stöcke, Butzen, Nester, etc. (Masses, pockets, etc.).
3. Stockwerke. (Stockworks).

(14).

A. v. Groddeck, *Lehre von den Lagerstätten, etc.*, 1879, p. 84.

I. Ursprüngliche Lagerstätten (Primary deposits).

A. Gleichzeitig mit dem Nebengestein gebildet. (Formed at the same time with the walls).

1. Geschichtete. (Stratified).

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(*a.*) Derbe Erzflötze. (Entire beds in fossiliferous strata).
(*b.*) Ausscheidungsflötze. (Disseminated in beds).
(*c.*) Erzlager. (Lenticular beds, mostly in schists).
2. Massige. (Massive, the word is nearly synonymous with igneous).
B. Später wie das Nebengestein gebildet. (Formed later than the walls).
3. Hohlräumsfüllungen. (Cavity fillings).
(*a.*) Spaltenfüllungen oder Gänge. (Fissure fillings or veins).
(1.) In massigen Gesteinen. (In igneous rocks).
(2.) In geschichteten Gesteinen. (In stratified rocks).
(*b.*) Höhlenfüllungen. (Chambers).
4. Metamorphische Lagerstätten. (Alterations, replacements, etc.).
II. Trümmer-lagerstätten. (Secondary or detrital deposits).

(15).

R. Pumpelly, Johnson's *Encyclopædia*, 1886, VI., 22.

I. Disseminated concentration.
(*a.*) Impregnations, Fahlbands.
II. Aggregated Concentration.
(*a.*) Lenticular aggregations and beds.
(*b.*) Irregular masses.
(*c.*) Reticulated veins.
(*d.*) Contact deposits.
} Forms due to the texture of the enclosing rock, or to its mineral constitution or to both causes.

III. Cave deposits.
IV. Gash veins.
V. Fissure veins.
} Forms chiefly due to pre-existing open cavities or fissures.

VI. Surface deposits.
(*a.*) Residuary deposits.
(*b.*) Stream deposits.
(*c.*) Lake or bog deposits.

These three are all excellent and give some interesting variations in the several points of view, from which each writer regarded his subject. There are instances in the two German

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schemes where it is difficult to render the original into a corresponding English term and recourse has been had to the explanatory text. Grimm, especially writes an obscure style. He divides accordingly as the ore forms an essential and integral part of the walls or a distinct body. V. Groddeck has in view the relative time of formation, as contrasted with the walls. Grimm afterwards emphasizes geometrical shape, but this v. Groddeck practically does away with, and continues more consistently genetic. His scheme might perhaps come more appropriately in the next section.

Pumpelly's conception varies considerably from the others. He writes, as his full paper states, in the belief that the metals have all been derived primarily from the ocean, whence they have passed into sedimentary, and by fusion of sediments, into igneous rocks. The group of residuary surface deposits, carrying out as it does a favorite idea of Professor Pumpelly, as set forth in his papers on the secular decay of rocks, is an important distinction.

E. *Schemes Entirely Based on Origin.*

(16).

H. S. Munroe. Used in the Lectures on Practical Mining in the Columbia School of Mines. Not hitherto published.

I. Of surface origin, beds.
  (*a.*) Mechanical (action of moving water).
    1. Placers and beach deposits.
  (*b.*) Chemical (deposited in still water).
    1. By evaporation (salt, gypsum, etc.).
    2. By precipitation (bog ores).
    3. Residual deposits from solution of limestone, etc. (hematites).
  (*c.*) Organic.
    1. Vegetable (coal, etc.).
    2. Animal (limestone, etc.).
  (*d.*) Complex (cannel coal, bog ores, etc.).

II. Of subterranean origin.
  (*a.*) Filling fissures and cavities formed mechanically.
    1. Fissure veins, lodes.
    2. Cave deposits—lead, silver, iron ores.
    3. Gash veins. The cavities of 2 and 3 are enlarged by solution of limestone.

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(*b.*) Filling interstitial spaces and replacing the walls.

1. Impregnated beds.
2. Fahlbands.
3. Stockworks.
4. Bonanzas.
5. Masses.

This scheme covers all forms of mineral deposits, whether metalliferous or not, while most of those previously given, as well as the one that follows, concern only metalliferous bodies. The scheme is consistently genetic and was elaborated because such an one filled its place in lectures on mining better than one based on form. It has not been hitherto printed and was not known to the writer until the remainder of the paper was practically complete, and then it came to his attention while talking the subject over with Professor Munroe. It gave such strong confirmation of views already set forth, the more, coming from the standpoint of practical mining, that it is gladly introduced. The general principle on which the main subdivision is made, differs materially from any hitherto given. Deposits formed on the surface are kept distinct from those originating below, even though the first class may afterward be buried.

(17).

J. F. Kemp, 1892.

I. *Of Igneous Origin.* Excessively basic developments of fused and cooling magmas. Ills. Peridotite (forming iron ore), at Cumberland Hill, R. I.* Magnetite, Jacupiranga, Brazil.† Magnetite in Minnesota gabbros.‡ Some magnetites in Gabbro, in the Adirondacks.§ Some Swedish and Norwegian magnetites.‖

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* M. E. Wadsworth, *Bull. Mus. Comp. Zool*, 1880, vii.

† O. A. Derby, *Amer. Jour. Sci.*, April, 1891, p. 311.

‡ N. H. Winchell, *10th Ann. Rep. Minn. Geol Surv.*, pp. 80–83; *Bulletin*, vi., p. 135.

§ Forthcoming paper by J. F. Kemp.

‖ J. H. L. Vogt, *Geol. Fören. i. Stockholm*, Förhand. xiii., 476, May, 1891. English Abstract and Review by J. J. H. Teall, *Geol. Mag.*, Feb, 1892.

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II. *Deposited from Solution.*

1. *Surface precipitations*, often forming beds, and caused by
   - (*a.*) *Oxidation.* (Bog ores, ferruginous oolites, as in some Clinton ores).*
   - (*b.*) *Sulphurous Exhalations.* (Pyrite.)
   - (*c.*) *Reduction.* (Pyrite from ferrous sulphate.)
   - (*d.*) *Evaporation*, cooling, loss of pressure, etc. (Hot-spring deposits, Steamboat Springs, Nev.)†
   - (*e.*) *Secretions of living organisms.* (Iron ores by algæ.)‡
2. *Amygdaloidal* fillings in igneous rocks. (Keweenaw Point copper-bearing amygdaloids; Santa Rita, N. M., copper deposits.)§
3. *Disseminations* (impregnations) in particular beds, or sheets, because of
   - (*a.*) *Selective porosity.* (Silver Cliff, Colorado, silver ore in rhyolite.‖ Silver Reef, Utah, in sandstone.¶ Keweenaw Point, in conglomerates.)
   - (*b.*) *Selective precipitation* by replaced limestones, organic reductions, sulphurous oils or gases, etc. (clay-ironstone, Leadville ores, Texas and New Mexico copper ores in Permian or Triassic** sandstone, also Silver Reef, Utah, in part. This sub-group is often related to 11.)

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* C. H. Smyth, Jr., *Amer. Jour. Sci.*, June, 1892, p. 487.

† G. F. Becker, Monograph, xiii., *U. S. Geol. Survey*, p. 331, p. 468. Laur, *Ann. des Mines*, 1863, p. 421. J. Leconte, *Amer. Jour. Sci.*, June, 1883, p. 424; July, 1883, p. 1. W. H. Weed, *Amer. Jour. Sci.*, August, 1891, p. 166.

‡ Sjogrun, *Berg. u. Hütt. Zeit.*, 1865, p. 116.

§ A. F. Wendt, *Trans. Amer. Inst. Min. Eng.*, xv., 27.

‖ Clark, *Eng. and Min. Jour.*, November 2, 1878, p. 314. C. W. Cross, *Proc. Colo. Sci. Soc.*, 1890, p. 269.

¶ C. M. Rolker, *Trans. Amer. Inst. Min. Eng.*, ix., 21.

** J. F. Furman, *Trans. N. Y. Acad. Sci.*, 1881–83, p. 15. J. S. Newberry, *E. and M. Jour.*, xxxi., p. 5, also October 23, 1884, p. 269; January 1, 1881, p. 4. *Tenth Census*, vol. xii., p. 40 and p. 473.

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4. *Filling Joints* caused by cooling or drying. (Miss. Valley gash veins in part.)
5. *Occupying Collapsed* (*brecciated*) *Beds*, caused by solution and removal of support, or, perhaps, from dolomitization of limestone. (Southwest Missouri zinc deposits.)*
6. *Occupying cracks at Monoclinal bends, Anticlinal summits, Synclinal troughs.* (Gash veins, in part;† lead deposits at Mine La Motte, Mo.; Saucon Valley, Pa., zinc mines.)‡
7. *Occupying Shear-zones* or dynamically crushed strips along faults, whose displacement may be slight. (Butte, Mont.)§
8. *Occupying Volcanic necks*, in agglomerates. (Bassick and Bull Domingo Mines, Colo.)‖
9. *True veins*, filling an extended fissure, often with lateral enlargements [see 3 *b*].)
10. *Occupying Chambers* (caves) *in limestone.* (Cave Mine, Utah.)¶
11. *Contact Deposits.*
    (*a.*) *Igneous rock* forms at least one wall. Fumaroles. (Marquette Hematites,** Greisen.)
    (*b.*) *Between limestone and dolomite.* (Aspen, Colo.)††
12. *Segregations formed in the alteration of igneous rocks.* (Chromite in serpentine.)

III. *Deposited from Suspension.*

1. *Metalliferous sands* and gravels, whether now on

* F. L. Clerc., *Lead and Zinc Ores in S. W. Mo. Mines*, Carthage, 1887. A. Schmidt, *Mo. Geol. Surv.*, 1874, p. 384.

† T. C. Chamberlain, *Wis. Geol. Surv.*, iv., 1882, 367.

‡ F. L. Clerc, *Mineral Resources, U. S. Geol. Surv.*, 1882, p. 361. H. S. Drinker, *Trans. Amer. Inst. Min. Eng.*, i., 367.

§ S. F. Emmons, *Trans. Amer. Inst. Min. Eng.*, xvi., 49.

‖ C. W. Cross, *Proc. Colo. Sci. Soc.*, 1890, p. 269.

¶ J. S. Newberry, *S. of M. Quarterly*, March, 1880. See also J. P. Kimball, on Santa Eulalia, Chihuahua, *Amer. Jour. Sci.*, ii., xlix., 161.

** C. R. Van Hise, *Amer. Jour. Sci.*, February, 1892, p. 116.

†† S. F. Emmons, *Proc. Colo. Sci. Soc.*, vol. ii., part iii., p. 251. C. Henrich, *Trans. Amer. Inst. Min. Eng.*, xvii., 156. A. Lakes, *Ann. Rep. Colo. School of Mines*, 1886. W. B. Newberry, *Trans. Amer. Inst. Min. Eng.*, June, 1889.

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the surface (Placers, magnetite sands) or subsequently buried. (Deep gravels, magnetite lenses?)

2. *Residual concentrations* left by weathering of matrix. (Iron Mountain, Mo., hematite, in part.)*

IV. *Deposits whose manner of origin is not fully proven.*

1. Lenticular beds (veins?) of pyrite or magnetite, in schists or gneiss.
2. So-called segregated veins of quartz, often auriferous, in schists parallel with the bedding.
3. So-called segregated veins of granite, often containing tin ores.
4. Iron ores, referred to submarine volcanic eruptions, and abnormally heated marine solutions. (Elba, Vermilion Lake District.†)
5. Iron ores, in acid igneous rocks supposed to be themselves igneous.

These terms are esteemed self-explanatory, but it may be remarked that for all those deposited from solution, except Nos. 1 (in part) and 12, the supplies of minerals have come in, either from the leaching of the wall rock or in uprising currents from below, which follow some more or less open water-way.

A few words of comment may be added on Group IV., which is regarded as problematical. Why are pyrite and magnetite so often in lenses that overlap like shingles and succeed one another in the footwall? Such deposits of magnetite might be formed in placers or delta deposits, but pyrite does not admit of this explanation. Is the lenticular shape due to cavities of lenticular cross-section formed by the buckling of schists under compression? If so, why the overlapping arrangement? Have they replaced beds of limestone, which have been stretched into this shape in dynamical metamorphism? So-called segregated veins of quartz may be in cavities due to movements along the bedding planes, but the question may be raised with reason, Do any of the other causes just cited, or still different ones, affect them? Are the so-

* R. Pumpelly, *Bull. Geol. Soc. Amer.*, ii., p. 220.

† N. H. Winchell, *Amer. Geol.*, iv., 291, 389. *Bull. VI. Minn. Geol. Surv.*

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called granite veins true veins or dikes? If the latter is sometimes true, is cassiterite an early crystallization from an igneous magma? The explanation of iron ores by submarine volcanic eruptions brings us face to face with phenomena of which we actually know little, and a conservative attitude impels one to regard the hypothesis with some questioning. The last case of the presence of any notable body of iron oxide in an acid igneous rock (as at Iron Mountain, Mo.), and itself of igneous origin, affords us two contradictory phenomena, which, under the laws of rock crystallization, as at present understood, would seem quite impossible.

There are a number of other terms often applied to ore bodies, such as "chimney," "pipe," "lode," "ledge," "chute," etc., which are either minor phenomena of the above, or are too indefinite to be placed in a scheme of classification as integral forms.

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RAPID QUALITATIVE EXAMINATION OF MINERAL SUBSTANCES.

By ALFRED J. MOSES, Ph.D. and J. S. C. WELLS, Ph.D.

This scheme is designed for the rapid determination of the essential constituents of minerals, and also for the preliminary examination which should precede separation into groups and thorough qualitative analysis. Preference is given to dry or blow-pipe tests, but where, as in silicates, these have proved unreliable, a simple wet method has been introduced.

The intention has been to outline a simple order of work and to give with this confirmatory tests in sufficient detail to enable any one at all familiar with analytical work to be sure of results, without having to refer at each step to some manual of tests.

The tests are given in large type, the confirmatory tests and notes in smaller type. A few abbreviations, such as S. Ph. for salt of phosphorus, soda for sodic carbonate, O. F. and R. F. for oxidizing and reducing flames, are used. The general outline is as follows:

I. Substances yielding noticeable coatings:
   - A. By gentle oxidation upon blackened plaster.
   - B. By reduction with soda upon charcoal.
   - C. By the aid of bismuth flux upon plaster.

II. Substances contained in the mass resulting from the fusion with soda on charcoal.
   - A. Magnetic particles.
   - B. Elements combined with the soda.

III. Substances which are not driven from a salt of phosphorus bead by reduction.
   - A. The bead in O. F. (cold) is colorless, or very faint yellow.
   - B. The bead in O. F. (cold) is yellow or greenish-yellow.
   - C. The bead in O. F. (cold) is violet.
   - D. The bead in O. F. (cold) is green.
   - E. The bead in O. F. (cold) is blue.
   - F. The saturated bead is either white and opaque cold or contains an appreciable amount of insoluble matter.

IV. Special tests for substances not included in I., II. or III.

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I. Substances yielding sub-

TEST A.—Heat a portion gently with O. F. upon a PLASTER

Sb.—White pulverulent volatile coat.

The compound often continues to form in dense white fumes after cessation of blast. The coating disappears before R. F. tingeing it a pale yellow green, or if scraped together, dissolved in S. Ph. and *just* fused on coal in contact with tin it will form a gray or black opaque bead.

As.—White very volatile crystalline coat.

The coat disappears before R. F., tingeing it pale blue and evolving a characteristic garlic odor.

There may also be formed non-volatile coatings of Sn or Zn near the assay, yellow hot, and white cold; yellow coatings of Pb or Bi; crystalline yellow and white coating of Mo; brick red to crimson coating and horseradish odor of Se and deep brown coatings of Cd and Te. All of these will be detected with greater certainty by later tests.

TEST B.—Heat a portion *gently*, with the R. F., on CHARCOAL, and and heat *strongly* with the R. F. for three or four minutes. Pre

As.—Garlic odor and a faint, white volatile coat.

Cd.—Dark brown volatile coat, sometimes shading to greenish-yellow and usually surrounded by a variegated coloration resembling the colors of peacock feathers.

Zn.—White not easily volatile coat, yellow when hot.

Sn.—White non-volatile coat close to assay, and usually small in amount.

White coats may form from Pb, Bi or alkalis, yellow coats from Pb or Bi, brown or red coats from Cu or Mo, and the ash of the coal may be white or red.

TEST C.—Mix a portion of the substance with more than an equal with the oxidizing flame.

Pb.—Chrome-yellow coat, darker hot, often covers the entire tablet.

Sn.—Brownish orange coat.

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* Charcoal may be used, but as plaster condenses the oxides closer to the assay, the able. See Moses, SCHOOL OF MINES QUARTERLY, vol. x., p. 321.

† Formed by grinding together 1 pt. KI, 1 pt. $KHSO_4$, 2 pts. S. See Moses, SCHOOL

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limates on plaster or charcoal.

TABLET which has been blackened in the lamp flame.*

CONFIRMATION Sb.—If the coating be scraped off and dissolved in tartaric acid + HCl, and the solution placed in a platinum capsule with a piece of zinc, antimony, if present, will give a black adherent stain.

Confirmed by washing the stain with water, then dissolving it in a few drops of hot tartaric acid plus a drop or two of HCl; on adding H_2S an orange precipitate = Sb.

CONFIRMATION As.—The coating may be dissolved in solution of KOH, placed in a test tube, a small piece of sodium amalgam added, and the tube covered with a piece of filter paper moistened with a *slightly* acid solution of $AgNO_3$. The paper will be stained black by the AsH_3 evolved.

---

note the results; then add a spoonful of soda and a little borax, serve the fused mass for subsequent examination by II.

CONFIRMATION Cd.—The coat forms at first heating, and if fused with $Na_2S_2O_3$ will form a bright yellow (CdS) mass.

CONFIRMATION Zn and Sn.—The zinc coat is made bright yellowish-green by moistening with dilute cobalt nitrate and igniting.

The tin coat becomes bluish-green on ignition with dilute cobalt nitrate.

If any coat forms, examine it for Zn and Sn by moistening it with cobalt solution and blowing a strong blue flame on the substance. The coatings from other elements will not prevent the cobalt coloration.

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volume of bismuth flux† and heat *gently* upon a PLASTER TABLET

CONFIRMATIONS *Test C* (general).—If the test with bismuth flux is made upon charcoal, there would result

Pb.—Greenish-yellow coat, brown near the assay.

As, Sb, Hg, Bi.—Very faint, volatile, yellow or reddish coat at a distance.

Sn.—By strong heat a white coat of the oxide.

Bi.—Bright-red band, with sometimes an inner fringe of yellow.

---

volatile coatings of arsenic and antimony upon it are much thicker and more notice-

OF MINES QUARTERLY, vol. x., p. 324.

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As.—Reddish-orange and yellow coat, darker hot.

Sb.—Orange to peach red coat, very dark when hot.

Hg.—Gently heated, bright yellow and scarlet coat, very volatile, becomes all scarlet on standing; but if quickly heated, the coat formed is pale yellow and black.

Bi.—Bright scarlet coat surrounded by chocolate-brown with sometimes a reddish fringe.

Large amounts of certain other elements may yield colored sublimates, and on smoked plaster certain white sublimates are obtainable: in all cases the elements are detected with greater certainty by other tests, but for convenience they are here summarized Se, reddish brown; Te, purplish-brown, with deep brown border; Mo, deep ultramarine blue; Cu, Cd, Zn, white (on smoked plaster).

II. Substances * contained in the mass

Crush and pulverize, collect any magnetic particles with the mag- moisten with water and let stand.

TEST A. Dissolve some of the magnetic particles in a borax bead

Fe.—The bead is: O. F. hot, yellow to red; O. F. cold, colorless to yellow; R. F. cold, bottle-green.

Ni.—The bead is: O. F. hot, intense violet; O. F. cold, pale brown; R. F. cold, colorless.

Co.—The bead is: O. F. and R. F. hot or cold, a deep pure smalt blue; if greenish when hot, probably Fe or Ni is also there.

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* There may be contained in the soda also metallic particles or buttons, which BRITTLE—Sb, white; Bi, reddish-white.

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CONFIRMATION As.—The coat becomes lemon-yellow when moistened with $(NH_4)_2S$.

CONFIRMATION Sb.—The coat becomes orange when moistened with $(NH_4)_2S$.

CONFIRMATION Hg.—If the substance is heated gently in a closed tube or matrass with dry soda or litharge, a mirror-like sublimate will form which may be collected into little globules of Hg, by rubbing with a match end.

CONFIRMATION Bi.—The coat is turned orange-yellow, then cherry-red, by fumes of NH_3, which may conveniently be produced by heating a few crystals of S. Ph. on the assay.

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resulting from the fusion with soda on coal.

net; place the balance of the powder upon a bright silver surface,

with the O. F. Try also effect of R. F.

CONFIRMATION Fe.—The magnetic particles yield with HNO_3, a brown solution from which, after evaporating excess of acid, K_4FeCy_6 throws down a blue precipitate.

CONFIRMATION Ni.—If the excess of acid be driven off by evaporation, KCy added in excess, and the solution then made strongly alkaline with KOH, two or three drops of pure bromine will give a black precipitate of $Ni_2(OH)_6$. Should the addition of the bromine make the solution neutral or acid, more KOH must be added until reaction becomes strongly alkaline.

CONFIRMATION Co.—The magnetic particles yield with HNO_3, a rose-red solution which becomes blue on evaporation.

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may be roughly recognized by color and tenacity as follows:

MALLEABLE—Ag, silver-white: Sn, white; Pb, gray; An, yellow; Cu, red.

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TEST B.—The bright silver is stained black or dark brown.

Unless the horseradish odor of Se or the brown coatings of Se and Te with bismuth flux have been already obtained, this stain will prove sulphur.

S.—The soda fusion will evolve H_2S, when moistened with HCl.

To distinguish sulphide from sulphate, fuse a little of the original substance with soda in a porcelain crucible, put a piece of bright silver in the crucible and add a little water. A black stain equals sulphide. Remove silver, dissolve fusion in hot water and filter, acidify filtrate with HCl. Evolution of H_2S if sulphide is present. Add $BaCl_2$, white precipitate equals sulphate.

Se.—Characteristic disagreeable horseradish odor during fusion.

Te.—The quite cold soda fusion added to hot water produces a purple-red solution.

III. Examination in salt

Dissolve substance in salt of phosphorus in O. F. so long as bead utes in a strong R. F. to remove volatile compounds. Note cold.

TEST A.—If the bead in O. F. cold is colorless or very faint yel- dissolve in hot dilute (¼) HCl with addition of a little metallic

Fe.—The reduced bead is colorless.

Ti.—The reduced bead is violet, the solution is violet and turbid.

Mo.—The reduced bead is green, the solution is dark-brown.

W.—The reduced bead is green, the solution is deep blue.

TEST B.—If the bead in O. F. cold, is colored yellow or greenish-

U.—In R. F. the bead will be dull green hot, fine green cold.

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* If any of I. and II. have been found except Co, Ni and Fe it is better to submi ally, and if it agglomerates, repulverize and again roast. Continue till no noticeable

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CONFIRMATIONS S.—By holding in the gas a piece of filter paper moistened with a drop or two of lead acetate (test is made more sensitive by adding a drop of ammonia to the acetate), the paper will be stained black.

The soda fusion dissolved in water will give a brownish black precipitate on addition of a solution of lead acetate in KOH.

The soda fusion moistened with water on a watch glass will yield a magnificent purple-red color on addition of sodium nitro-prusside.

CONFIRMATION Te.—If a little of the original substance is dropped into boiling concentrated H_2SO_4 a deep violet color is produced, this disappears on further heating.

---

of phosphorus bead.*

remains clear on cooling. Treat then for three or four min- the colors hot and cold, then re-oxidize and note colors hot and

low, reduce it on coal with tin, and if then colored pulverize and tin.

CONFIRMATION Fe.—The bead in its previous treatment should have been O. F. hot, yellow to red; O. F. cold, colorless; R. F. cold, bottle green.

CONFIRMATION Mo.—Heat a little of the substance in Pt foil with a few drops of conc. HNO_3, heat until excess of HNO_3 has all volatilized, then add a few drops of strong H_2SO_4 and heat until copious fumes are evolved; cool, and breathe upon the cooled mass, an ultramarine blue = Mo.

Heat substance on charcoal in O. F.; scrape off coating obtained, dissolve in NH_4OH and *add to an excess of* HNO_3; then add one drop of dilute solution of Na_2HPO_4, a yellow ppt. = Mo. (As must not be present.)

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yellow, treat it in a strong reducing flame.

CONFIRMATION U.—Make a Na_2CO_3 fusion, dissolve in HCl or H_2SO_4, add a few drops of H_2S water, and if it gives any precipitate, add it in excess and filter; to filtrate add a few drops of HNO_3 and boil, then add NH_4OH to alkaline reaction, filter, wash precipitate with ammonia water, and then treat precipitate with a concentrated solution of $(NH_4)_2CO_3 + NH_4OH$, filter and acidify filtrate with HCl, and add K_4FeCy_6. Brown ppt. = Ur.

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the substance to a slow heating in the O. F. and R. F. Turn the material occasion- fumes are given off.

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V.—In R. F. the bead will be brownish hot, fine green cold.

Ni.*—In R. F. the bead will be reddish hot, yellow cold.

TEST C.—If the bead in O. F., cold, is colored violet, touch the

Mn.—The bead is made deep permanganate color.

TEST D.—If the bead in O. F., cold, is colored green, the sub- with the addition of nitre or $KClO_3$,

Cr.—A bright chrome yellow.

There may be green bead from admixture of a blue and a yellow. If Cr is not proved, examine in such a case by tests B and E with unusual care.

TEST E.—If the bead in O. F., cold, is colored blue.

Co.—The bead is deep blue, hot and cold, in both flames.

Cu.—The bead is green, hot, greenish-blue, cold, and on reduction becomes opaque brownish-red.

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* If the absence of Ni is not proved, or Co obscures the tests, dissolve the substance
If a visible button results, separate it from the borax, and treat with S. Ph. in the
If no visible button results, add either a small gold button or a few grains of test
quently changed boracic acid to small size, stopping the instant the boracic acid is
Complete the removal of lead by O. F. on coal, and treat as below.
Treat the gold alloy, or the residual button from the lead alloy, on coal, with fre-
The metals which have united with the gold or lead will be successively oxidized,
Co.—Blue, hot; blue, cold. May stay in the slag.
Ni.—Brown, hot; yellow, cold. May give green with Co or Cu.
Cu.—Green, hot; blue, cold. Made opaque red by Sn and R. F.
The slag should contain the more easily oxidizable metals, and be free from Cu, it must be removed by further reduction with Pb. Pulverize the slags and dissolve a

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CONFIRMATION V.—Fuse substance with Na_2CO_3 in O. F. and dissolve fusion in a few drops of dilute H_2SO_4 or HCl, add a piece of zinc and warm; blue color changing to green and finally violet = V.

Or, shake acid solution with ether and hydrogen dioxide, and if V is present, the aqueous solution becomes red.

CONFIRMATION Ni.—The hot bead in O. F. will be intense violet.

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bead while hot to a crystal of nitre.

---

stance is fused with a paste of soda on platinum wire in the O. F.,

CONFIRMATION Cr.—If the soda bead is dissolved in water; filtered, if necessary, acidified with acetic acid and a drop or two of plumbic acetate added, a yellow precipitate will be formed.

By dissolving the soda bead in water, acidifying with H_2SO_4 and adding it to a very dilute solution of hydrogen dioxide covered with a layer of ether, on closing the test tube with the thumb and inverting it two or three times, the ether will become blue

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CONFIRMATION Cu.—Boil a few grains of the substance with strong HNO_3, add excess of NH_4OH, deep blue solution = Cu. Acidify blue solution with acetic acid and add K_4FeCy_6. Reddish-brown precipitate = Cu.

---

in borax on coal to saturation, and treat for five minutes in hot R. F.
O. F., replacing the S. Ph. when a color is obtained.
lead. Continue the reduction, and, if lead has been used, scorify the button with fre-
colored, by Co, Ni or Cu, blue, yellow or red respectively.

quently changed S. Ph. in strong O. F.
and their oxides will color the S. Ph. in the following order:

Ni and Ag. Test a portion with S. Ph. and Sn to prove absence of Cu. If present portion in S. Ph. and examine by III.

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TEST F.*—If the saturated bead in O. F. is white and opaque,

This result may be due to one or more of Ba, Ca, Sr, Mg, Al, SiO_2, Sn, Ti, and

SiO_2.—The insoluble material is in the form of a *translucent* cloud, jelly-like mass, or skeleton form of the original material added.

(a) Treat the finely pulverized mineral with Zn and HCl in con- with $HgCl_2$.

Sn.—White or gray ppt.

(b) Moisten the roasted substance with cobalt solution, and heat

Mg.—Pale pink or flesh color. Violet if present as either arsenate or phosphate.

Al.—Beautiful blue, infusible.

SiO_2.—Faint blue.

There may also be blues from fusible silicates, phosphates and borates, greens from oxides of Zn, Sn, Ti, Sb, violet from Zr and various indefinite browns and grays.

(c) Moisten the flattened end of a clean platinum wire with dilute strongly at the tip of the blue flame, and gently near the

Ba.—Yellowish-green flame, bluish-green through green glass.

Ca.—Yellowish-red (brick-red) flame, green through green glass.

Sr.—Scarlet-red flame, faint yellow through green glass.

This test may also show:

Li.—Carmine-red flame, invisible through green glass.

K.—Rose-violet flame, reddish-violet through blue glass.

Na.—Orange-yellow flame, invisible through blue glass.

There may also be produced **Cu** azure blue and emerald green; **Se** and **As** pale blue; **Mo, Sb, Te** pale green.

When tests (b) and (c) fail to give satisfactory results, proceed as follows:

(d) Remove the volatile constituents as thoroughly as possible twice the quantity of NH_4F, and a few drops of concentrated and H_2SO_4, and heat again in the same way. To the residue drops of H_2SO_4, and heat ten or fifteen minutes at a temper- no more SO_3 is given off, then add a few drops of concen- When fusion is quite cold, dissolve in cold water and filter.

Residue a.—Boil with strong solution of $(NH_4)_2SO_4$ and filter.

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* In addition to SiO_2 we have here the natural alumina and aluminates, oxides fail in most natural silicates, especially where the substance is dark colored or fusible.

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when cold, or contains an appreciable amount of insoluble material.

there may be revealed also Li, K, Na, Fe, etc.

CONFIRMATION SiO_2.—Mix the *dry* substance with a little *dry* fluoride (free from SiO_2), place in a *dry* test tube and add H_2SO_4 (conc.) and heat gently, hold in fumes given off, a drop of water in loop of platinum wire; SiO_2 will be separated on coming in contact with the water, forming a jelly-like mass.

tact with platinum.† Dissolve any reduced metal in HCl and test

strongly.

hydrochloric acid, dip it in the roasted substance, and heat wick. Remoisten with the acid frequently.

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by roasting, then heat gently in a platinum capsule, with about H_2SO_4 as long as fumes are given off; add a little more NH_4F in the capsule, add two or three parts of $KHSO_4$, and a few ature just sufficient to slowly drive off fumes of SO_3. Heat until trated H_2SO_4, and heat again for a minute.

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of tin, oxide of titanium, etc. The usual reactions for Ba, Ca, Sr, Mg, Al, also

† See Wells, S. OF M. QUART.

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Residue b.

Moisten with concentrated HCl and try coloration of flame.

Ba.—Yellowish-green flame.

Sr.—Scarlet flame.

Filtrate b.

Add a few drops of H_2S water; if any precipitate forms, saturate with H_2S and filter, and to filtrate add NH_4OH and $(NH_4)_2C_2O_4$.

Ca.—A white precipitate.

Filtrate a.—Divide into four parts and test as follows:

1°. Add a piece of Zn or Sn and a little HCl, and heat.

Ti.—A violet or blue solution.

2°. Add excess of KOH * or NaOH, boil and filter, and to filtrate add excess of NH_4Cl. and boil.

Al.—White precipitate.

Dissolve ppt., produced by the KOH or NaOH, in HCl, and add K_4FeCy_6.

Fe.—Blue precipitate.

3. Add $NH_4OH + (NH_4)_2 S$ in *slight* excess and filter; to filtrate add Na_2HPO_4.

Mg.—White *crystalline* precipitate.

4°. Add $BaCl_2$ as long as it gives a precipitate, then $Ba(OH)_2$ to NH_4OH and heat, filter; evaporate filtrate to dryness and Na; dissolve residue in a few drops of water (filtering if neces-

K.—Yellow cryst. ppt.

IV.—Special tests for substances

TEST A.—Cupellation for silver and gold. Fuse one spoonful of 2 vols. of test lead in R. F. for about two minutes. Remove on cupel and blow O. F. *across* it, using as strong blast and If the litharge is dark, or if the button freezes before brightening, borax, add more test lead, and again cupel until there re-

* Be sure that the KOH or NaOH is free from Al and SiO_2; they are common

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CONFIRMATION Ba and Sr.—Or may test residue b as follows: Fuse with two to three pts. of soda in a platinum capsule; treat fusion with boiling water, filter, reject filtrate, dissolve residue in acetic acid, add a few drops H_2S water, if it gives any precipitate, saturate with H_2S and filter, and to filtrate add $K_2Cr_2O_7$. **Ba** = yellow precipitate. Filter and to filtrate add $CaSO_4$ warm and let stand. **Sr** = white precipitate.

CONFIRMATIONS Ti.—Nearly neutralize solution, and then add $Na_2S_2O_3$, and boil White ppt. = Ti.

Or, make solution slightly alkaline, and then acidify slightly with HCl, and add Na_2HPO_4. White ppt. = Ti.

CONFIRMATION Mg.—If phosphates are present this test would not be reliable for Mg. In such cases test a few drops of the solution with H_2S; if it causes any precipitate, saturate the whole of the solution with it, filter, and to filtrate add a few drops of HNO_3, and boil (to oxidize FeO), nearly neutralize with solution of Na_2CO_3 (if iron is not present, add a few drops of Fe_2Cl_6, enough to give a red precipitate with the sodium acetate), dilute and add excess of sodium acetate, and boil, filter, and to filtrate add $NH_4OH + (NH_4)_2S$, filter, to filtrate add Na_2HPO_4. White crystalline precipitate = Mg.

alkaline reaction, boil, filter, and to filtrate add $(NH_4)_2CO_3$ and ignite to drive out NH_3 salts. Test residue in flame for K and sary) and then add H_2PtCl_6 ($PtCl_4$) and alcohol.

CONFIRMATIONS Na, K.—Mix 1 part of the silicate with 5–6 parts of $CaCO_3$ (precipitated) and 1 part of NH_4Cl, heat to redness in platinum capsule for thirty minutes (apply heat gently at first), digest sintered mass in hot water, and filter; to filtrate add $(NH_4)_2CO_3$ and NH_4OH, heat and filter, evaporate filtrate to dryness and ignite gently until all ammonia salts are driven off, then determine Na and K as above.

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not included in I. II., III.

roasted substance on charcoal with 1 vol. of borax glass, and 1 to button and scorify it in R. F. with fresh borax, then place button as little flame as are consistent with keeping the button melted. or if it brightens but is not spherical, rescorify it on coal with mains:

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impurities.

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Ag.—A bright white spherical button unaltered by further blowing.

Au.—A residue, after boiling the button in HNO_3, which becomes golden-yellow on ignition.

TEST B. Heat substance in matrass with potassic bisulphate.

N_2O_5.—Reddish-brown vapor with characteristic odor.

Br.—Reddish-brown, choking vapor.

Cl.—Yellowish-green vapor.

I.—Violet choking vapor.

Fl.—The glass of the mattrass is corroded, and if SiO_2 is present a film of SiO_2 is often deposited.

There may also be evolved various colorless gases, such as SO_2, H_2S, CO_2, etc. which are more safely recognized by other tests.

TEST C.—Heat the substance gently with water to remove air

CO_2.—Effervescence continuing after heat is removed.

H_2S, Cl. and H. are sometimes evolved, but usually the odor will distinguish these.

TEST D.—Place a piece of Mg wire in a closed tube, and cover mass takes fire, cool and add water.

P.—Evolution of phosphuretted hydrogen.

TEST E.—Make a paste of four pts. $KHSO_4$, one pt. CaF_2, water

B.—Just after water is driven off there will be a bright green flame.

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CONFIRMATION Ag.—Dissolve in a drop of HNO_3, and add a drop of HCl, producing a white curd-like precipitate.

CONFIRMATION N_2O_5.—Heat in test tube with a small piece of copper or copper filings, and conc. H_2SO_4, red or brown fumes = nitrates or nitrites.

CONFIRMATIONS Br, Cl, I.—Saturate a salt of phosphorus bead with CuO, add substance, and treat in O. F. Br, azure blue and emerald green flame. Cl, pure azure blue flame. I, emerald-green flame.

Fuse with Na_2CO_3, pulverize and mix with MnO_2, and add a few drops of conc. H_2SO_4, and heat. Cl, yellowish-green gas that bleaches vegetable colors. Br, red fumes.

Fuse with Na_2CO_3, dissolve in water, make slightly acid with H_2SO_4, and add $Fe_2(SO_4)_3$ (Ferric alum may be used), and boil; I, violet fumes (turn starch paper blue).

CONFIRMATION Fl.—If the substance be mixed with silica and then heated with concentrated sulphuric acid, and the fumes caught on a drop of water held in a loop of platinum wire, gelatinous silica will form in the water.

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bubbles and then with dilute hydrochloric acid.

CONFIRMATION Co_2.—If the gas is passed into lime water, a white cloud and ppt. will be produced.

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the wire with a mixture of soda and the substance. Heat till the

CONFIRMATIONS P.—Fuse a little of the substance (previously roasted if it contains As) with two or three pts. Na_2CO_3 and 1 $NaNO_3$, dissolve in HNO_3, and add excess of $(NH_4)_2MoO_4$, yellow ppt. = P_2O_5. In presence of SiO_2 it is well to confirm this ppt. by dissolving it in dilute NH_4OH, allowing it to stand for half an hour and filtering off any SiO_2 that separates, then to filtrate adding magnesia mixture. ($MgCl_2 + NH_4Cl + NH_4OH$) and white ppt. = P_2O_5.)

Or, take nitric acid solution of fusion, make alkaline with NH_4OH, then acidify with acetic acid and add drop or two of Fe_2Cl_6, yellow white ppt. = P_2O_5.

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and substance. Treat at tip of blue flame.

CONFIRMATION B.—Heat some of the substance gently on platinum wire, then add a drop of concentrated H_2SO_4, heat very gently again, just enough to drive off excess of H_2SO_4, dip in glycerine, hold in flame until glycerine begins to burn, remove from flame, and the mass will continue burning with a green flame.

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THE VOLUMETRIC ESTIMATION OF ZINC.

By BERTRAND C. HINMAN, Ph.B., A.M.

The Colorado Scientific Society outlined a plan, some time ago, of endeavoring to establish a uniformity in the technical methods of analysis in the West. For its first effort, a committee of several chemists was appointed to investigate the methods for the determination of zinc in ores, and their report was presented to the Society in June, 1892.

The ores submitted were from widely separated localities in Colorado; they were mixtures of galenite, pyrite, and sphalerite, accompanied by greater or less percentages of manganese in the form of rhodochrosite, associated with a quartzose gangue.

To obtain a standard of comparison, the samples of ore submitted by the committee were analyzed by Mr. L. G. Eakins, of the U. S. Geological Survey. The method followed by him was the conventional one—in short, as follows:

The ore was extracted with aqua regia, and the solution precipitated with sulphuretted hydrogen. In the filtrate from this precipitation the iron was separated by precipitating twice as basic acetate, and once with ammonia. In these filtrates, combined and acidulated with acetic acid, the zinc was precipitated as sulphide, dissolved, precipitated as carbonate, and weighed as oxide.

Several chemists of metallurgical works in Colorado made analyses of the samples, and their methods and results are given in the report. They were, however, essentially like, or modifications of, the method of Messrs. Von Schultz and Low, which received the approval of the committee. The operation is as follows:

"Prepare a solution of ferrocyanide of potassium by dissolving 44 grammes of the pure salt in distilled water and diluting to 1 litre. Standardize as follows:

"Dissolve exactly 200 milligrams of pure oxide of zinc in a beaker in 10 c.c. of strong, pure hydrochloric acid. Now add 7 grains of C. P. chloride of ammonium (the commercial article frequently contains a little copper), and about 100 c.c. of boiling-hot water. Titrate the clear liquid with the ferrocyanide solution until

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a drop, when tested on a porcelain plate with a strong aqueous solution of acetate of uranium, shows a brown tinge. About 16 c.c. of ferrocyanide will be required, and accordingly nearly this amount may be run in rapidly before making a test, and then the titration finished carefully by testing after each additional drop of ferrocyanide. As soon as a brown tinge is obtained, note the reading of the burette, and then wait a minute or two, and observe if one or more of the previous tests do not also develop a brown tinge. Usually, the end point will be found to have been passed by a test or two, and the proper correction must then be applied to the burette reading. Finally, make a further deduction from the burette reading of the amount of ferrocyanide necessary to produce a brown tinge under the same conditions when no zinc is present. This correction is about 2 drops, or 0.14 c.c.

" 200 mg. of oxide of zinc contain 160.4 mg. of zinc, and 1 c.c. of the above standardized solution will equal about 0.01 grains of zinc, or about 1 per cent. when 1 gramme of ore is taken for assay.

" Prepare the following solutions for the assay of ores:

" A saturated solution of chlorate of potassium in nitric acid, made by shaking an excess of the crystals with the strong pure acid in a flask. Keep the solution in an open flask.

" A dilute solution of chloride of ammonium, containing about 10 grammes to the litre. For use, heat to boiling in a wash-bottle.

" A wash-bottle of hot water.

" Take exactly one gramme of the ore, and treat with 25 c.c. of the above chlorate solution Do not cover the casserole at first, but warm gently until any violent action is over and greenish vapors have ceased to come off. Then cover with a watch-glass and boil rapidly to complete dryness, but avoid overheating and baking. A drop of nitric acid adhering to the cover does no harm. Cool sufficiently, and add 7 grammes of chloride of ammonium, 15 c.c. strong ammonia water, and 25 c.c. of hot water. Boil the covered mixture one minute, and then, with a rubber-tipped glass rod see that all solid matter on the cover, sides, and bottom of the casserole is either dissolved or disintegrated. Filter into a beaker, and wash several times with the hot chloride of ammonium solution. A blue colored filtrate indicates the presence of copper. In that case, add 25 c.c. of strong, pure hydrochloric acid and about 40 grammes of granulated test-lead. Stir the lead about in the beaker until the liquid has become perfectly colorless, and then a little longer to make sure that the copper is all precipitated. The so-

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lution, which should still be quite hot, is now ready for titration. In the absence of copper, the test-lead is omitted, and only the acid added. About one-third of the solution is now set aside, and the main portion is titrated rapidly with the ferrocyanide until the end point is passed, using the uranium indicator as in the standardization. The greater part of the reserved portion is now added, and the titration continued with more caution until the end-point is again passed. Then add the remainder of the reserved portion, and finish the titration carefully—ordinarily, by additions of two drops of ferrocyanide at a time. Make corrections of the final reading of the burette precisely as in standardization.

"Gold, silver, lead, copper, iron, manganese, and the ordinary constituents of ores do not interfere with the above scheme. Cadmium behaves like zinc; when known to be present, it may be removed, together with the copper, by the proper treatment with sulphuretted hydrogen; and the titration for zinc may be made upon the properly acidified filtrate, without the removal of the excess of gas. There seems to be no simpler way of removing cadmium.

"Notes on the above scheme:

"Acids destroy the delicacy of the uranium test, and for this reason a strong aqueous solution of uranium acetate is used. By having the zinc solution only faintly acid, the production of the brown color in the end-test becomes almost instantaneous, and no previous test will develop a color. Under these conditions, however, lead is apt to seriously interfere, and the excess of acid recommended above is found to be a necessity. When a strong solution of uranium acetate, not acidified, is used as an indicator, the error caused by the excess of acid in the zinc solution amounts to only two drops of ferrocyanide, which may be allowed for, and the brown tinge develops so rapidly that the end-point is seldom passed by more than one test.

"When an ore contains but little copper, the granulated lead used frequently coheres in lumps that may hold zinc solution. These lumps are most easily broken up after a little of the ferrocyanide has been added. They appear to cause no appreciable error in the work. Of course, lead shot or thin sheet-lead may be used, if preferred, and it may be cleaned with strong nitric acid and used repeatedly. It seems simpler and more satisfactory however, to use the granulated lead and throw it away after use.

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"As regards the use of nitric acid, it is found that the addition of 1 c.c. of the strong acid to the boiling-hot zinc solution during the standardization of the ferrocyanide, makes no appreciable difference."

The ores upon which these experiments were made, were all from one section of country, and in general, were ores adapted to lead smelting. It seemed advisable, therefore, to try the method upon ores from other places containing associated minerals different from the above. The Franklinite and Calamine ores are among the most important sources of zinc, and are very frequently dealt with in the metallurgy of that metal. Upon such ores most of the experiments were made.

The solutions were prepared as directed, with the exception that, for standardizing, metallic zinc was used instead of the oxide. The standardizing of the ferrocyanide solution presented no difficulty. If the solution is hot, the end-reaction shows promptly, but the amount of hydrochloric acid present must be regulated with some care, as an excess over that used at the time of standardizing will delay the end-reaction in titration to a sensible degree. The practice adopted in making these experiments was to add a drop or two of methyl orange (though other indicators will answer equally well), bring the solution to the neutral point, and then add a known excess of hydrochloric acid. The color produced by the indicator in no wise interferes with the end-reaction during titration. By observing this simple precaution, the solutions may always be of the same degree of acidity, insuring perfect uniformity in the appearance of the end-reaction.

At times, in dissolving the ore, all the potassium chlorate will not be decomposed, so that, when the solution is made acid with hydrochloric acid, just prior to titration, euchlorine will be set free. When using an indicator to determine the neutral point, its presence is manifested by its bleaching action upon the color. It is well, then, to add a few drops of a solution of an alkaline sulphite.

To test the process, a Calamine ore containing 66.80 per cent. of zinc was carefully treated by the above-described method. There was obtained 65.14 per cent. of zinc. The ore contained but little manganese, and the precipitate produced by the addition of the excess of ammonia consisted almost entirely of ferric hydrate. The residue and the precipitate was treated again with the chlorate

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mixture, the solution obtained evaporated to dryness, an excess of ammonia again added, and in the filtrate from this precipitation was found 1.62 per cent. of zinc, making a total of 66.76 per cent. The experiment was repeated twice more in the same manner as at first. The three results were as follows:

	First Extraction.	Second Extraction.	Total.
Per cent. of zinc, . . .	65.14	1.62	66.76
Per cent. of zinc, . . .	65.37	1.41	66.78
Per cent. of zinc, . . .	65.35	1.41	66.76

The precipitated ferric hydrate held each time about one and one-half per cent. of zinc. This is a well-known phenomenon, but no mention of it seems to have been made by Messrs. von Schultz and Low in their description. This is undoubtedly because the ores worked by them contained so little iron that no appreciable difference was made by its presence.

In a fourth experiment on this ore an attempt was made to avoid the re-precipitation of the ferric hydrate by evaporating the solution of the ore in the acid to dryness, and taking up with water instead of ammonia. Ferric nitrate seems to lose its nitric acid more readily than zinc nitrate, and by proceeding in this manner a filtered solution may be obtained containing only a small amount of iron. There was, however, enough present, so that it was necessary to remove it with an excess of ammonia. There was found as a result 66.45 per cent. of zinc.

In order to determine the effect which the presence of manganese might have, a gramme of this same ore was mixed with 0.200 gramme of pyrolusite, and treated precisely as at first. There was found 66.76 per cent. of zinc, the manganese not changing the result. Thinking, perhaps, that the manganese dioxide would not be sufficiently decomposed in the strongly oxidizing solution used in decomposing the ore, another experiment was made upon the same ore with the same amount of pyrolusite present, but the mixture was first treated with hydrochloric acid to carry the dioxide of manganese into solution; nitric acid was added to expel the hydrochloric acid, and then the mixture was treated with the chlorate solution, and the analysis finished in the same manner as the previous ones. There was found 66.808 per cent. of zinc.

It may be safely concluded, then, that the presence of manganese does not interfere, and that it can be completely separated from zinc by oxidation to manganese dioxide in nitric acid solution.

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A Franklinite ore containing 20.86 per cent. of zinc and considerable manganese was next tried. The first treatment of this ore gave as its result only 15.60 per cent. The residue re-treated with acid as before yielded 1.01 per cent., and the residue from this again treated gave up 0.50 per cent., making a total of 17.11 per cent. of zinc, or nearly four per cent. low. The experiment was repeated upon another portion of the same sample. There was found only about 15 per cent. of zinc. The residue was re-treated as before and a little over 1 per cent. was found. The residue from this treatment was dissolved in hydrochloric acid, the iron separated as basic acetate, the filtrate made acid with acetic acid, sulphuretted hydrogen gas passed into it, and an abundant precipitate of zinc sulphide was obtained.

Evidently the solvent action of the nitric acid containing the potassium chlorate was not sufficient to completely decompose the ore, so in the next experiment the following treatment was adopted.

The ore was first digested with aqua regia; nitric acid was then added, and the mixture evaporated until all the hydrochloric acid had been expelled, the whole evaporated nearly to dryness, the regular amount of the nitric acid solution of the potassium chlorate was added and the analysis finished as usual. As a result of this procedure, there was obtained 20.81 per cent. of zinc.

A Franklinite, containing 23.53 per cent. of zinc, analyzed in duplicate in this manner, gave results respectively 23.54 per cent. and 23.34 per cent. of zinc. Still another sample of the same kind of ore having 31.42 per cent. was found by the same treatment to contain 31.613 per cent.

Some of the ores tried, although very finely pulverized in an agate mortar, were yet not entirely soluble in aqua regia, and it was necessary to fuse the residue in order to effect complete solution.

Copper was found to be easily separated in the manner described by the originators of the method, and the lead introduced, and that which might otherwise be present, was found to have no injurious effect. In fact, at the end of a titration with the brown tint just faintly showing with the uranium acetate, a large excess of lead acetate was added without changing at all the end reaction.

The method of von Schultz and Low, as given by them, will answer for ores easily decomposed and containing little or no iron, but to adopt the method to all ores of zinc or compounds contain-

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ing it, cadmium alone excepted (which, if present, must be removed with sulphuretted hydrogen), certain modifications are necessary. Guided by the preceding experiments the following practice would seem most advisable.

Pure metallic zinc is more easily obtainable for standardization than the pure oxide. In standardizing and in actual analysis, that the right degree of acidity be uniformly maintained, the use of a color-indicator in the solution is advised. It seems to be easier and simpler to work to the neutral point this way than to do it by means of test-papers, and the slight tint of color necessary to show the change to the eye does not impair the end-reaction with the ferrocyanide.

The ore, if at all refractory, should be very finely pulverized. A few moments spent in grinding will be more than compensated in the ease with which solution may be obtained.

Treat the finely divided ore with aqua regia until there is obtained complete decomposition, or until no further action is perceptible. If the ore has not been thoroughly decomposed, evaporate to dryness, dehydrate the silicic acid, take up with dilute hydrochloric acid, filter off the insoluble matter and fuse it with carbonate and nitrate of soda in a platinum crucible. Dissolve the fusion in hydrochloric acid and add the solution to the major portion. The dehydration of the silicic acid will consume some time, but if the ore is highly siliceous, the gain of time in filtering the sandy precipitate of silica as contrasted with filtering the gelatinous silicic acid will be more than repaid. All the zinc in the ore will now be in solution as chloride. Add nitric acid and boil until all the hydrochloric acid has been expelled; evaporate nearly to dryness, add the usual quantity of nitric acid saturated with potassium chlorate, and evaporate to dryness. Add the ammonium chloride and ammonia, dilute with water, heat to boiling and filter, washing with a weak solution of ammonium chloride made alkaline with ammonia. Transfer the precipitate from the paper, by means of a spatula and wash-bottle, to the vessel in which the ore was originally decomposed, evaporate off the water, and treat again with the chlorate mixture in the same manner as before, adding the solution obtained by treatment with ammonia to the original one. Acidify to the right degree with hydrochloric acid, heat nearly to boiling, and titrate with the standard ferrocyanide as described.

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The details of the method as here worked out are more numerous than these given in the original article of von Schultz and Low, but it is apparent that to secure accuracy of results under varied conditions, they are necessary. It is still very much shorter than the conventional one, and carefully worked ought to give results nearly if not quite as accurate, and certainly the difficulties in manipulation are not so great.

In conclusion, I desire to thank Professor Elwyn Waller for his valuable suggestions in the preparation of this paper.

NOTE ON THE GEOLOGY OF THE MONTE CRISTO DISTRICT, SNOHOMISH COUNTY, WASHINGTON.*

By C. W. FENNER.

Geologically, this region is very interesting. As you would suppose from the location it is in a region of extinct volcanic activity, and all the rocks show their igneous formation, but their characters differ greatly. They probably represent a number of separate flows, or perhaps are only due to different conditions of cooling. The most abundant rock is a massive granite. There is also what I should call diorite, at times, amygdaloidal. There are also porphyry, volcanic breccia and rocks showing a flow structure and consisting of quartz and some dark material. I have not seen anything which resembled scoria, but, on the contrary, the rocks are usually very dense and hard. Through these rocks, usually in the granite or diorite, the veins cut. They apparently follow true fissures and crushed strips in the country rock. In some of them the phenomena of fissure-veins show up well. I have seen slickensides in a number of cases, and have also found the clay selvage in one, but this is usually absent. Often breccia of country rock is included and sometimes coated with bands of ore and gangue. Large horses of rock also come in, and in some cases the vein becomes split up into a number of small stringers and is hard to trace. Quartz is a frequent gangue mineral and often shows the comb-in-comb structure. The minerals consist of

* Extract from recent letter.

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galena, pyrite, arsenopyrite, chalcopyrite, sphalerite, and perhaps a little bornite. All that is of value is the galena and the gold and silver that they all carry. The outcrops show very prominently and can be traced for long distances. Their inclination is usually steep, often nearly 90°. The general course is N. E. and S. W.

Often the outcrop is marked by a ravine or gulch, and the vein is so plain that the first one in the district was discovered with a field-glass.

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MINERALOGICAL NOTES.

A Probably New Nickel Arsenide.

(Preliminary Notice.)

By E. WALLER and A. J. MOSES.

Last April Mr. E. M. Hand, of Silver City, New Mexico, sent to the School of Mines several samples of silver ore composed in part of native silver but intermixed with a gray metallic mineral of granular structure, which was known to contain a considerable percentage of nickel and arsenic and some cobalt.

The ore is found at a mine eighteen miles west of Silver City, in the Bullard's Peak Mining District, Grant County, New Mexico, and was said to run 300 to 500 ounces of silver per ton and 25 to 35 per cent. of nickel. According to the analysis herein recorded, however, this estimate of nickel was considerably too high. The description of the deposit given by Mr. Hand is as follows: "The mine from which this ore comes has been worked to a depth of 690 feet by shaft and very extensive drifts. On the surface the ore is pure native silver, and the nickel or gray-looking mineral does not put in an appearance until a depth of over 100 feet has been reached. The vein occurs in a syenite and is crossed in several places by huge porphyry dykes. Rich ore-bodies are invariably found as the drifts or levels approach these dykes. The strike of the vein is east and west, and it dips to the north at an angle of about 20° from the perpendicular All the ore is of exceedingly high grade in silver and carries a heavy percentage of nickel."

The native silver is crystalline, and surrounded by the gray mineral, and on polishing an arborescent structure is revealed somewhat like that of the mineral huntilite. The gangue is chiefly carbonate of iron. As it was impossible to obtain lumps of the nickel mineral or to separate it from the silver and siderite by any hand-picking, the following mechanical method was resorted to: The mineral was crushed roughly in a steel mortar and the lumps most free from silver carefully picked out; these were then rubbed down in an agate mortar and put through a hundred mesh sieve by which the malleable silver was very largely

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held back as scales, and the brittle nickel mineral and siderite passed through. The powder was then heated in dilute hydrochloric acid by which all the siderite was dissolved. A little of the nickel mineral was also dissolved, but the Ni obtained from the solution amounted to only about $\frac{2}{10}$ per cent., and this would affect the analysis of the mineral only in so far as there should be a solution of this constituent without a proportionate solution of the other constituents. It was thought that the complete solution of the siderite would not be assured without treatment for a considerable time. It is not at all probable that all the native silver was by this method separated, and it is our purpose to make a further and more careful examination later.

The characters of the granular (nickel) mineral as far as obtained were:

Hardness about 5; lustre, metallic; color, gray, sometimes iridescent; streak, black; granular. On charcoal before the blowpipe blackens, fuses, yields arsenical odor, and becomes magnetic. In closed tube gives a ring of metallic arsenic. With borax, yields a cloudy blue bead; successive portions of salt of phosphorus, after removal of arsenic and iron, were colored blue (Co), violet (CoNi), brown hot, yellow cold (Ni), brown hot, opalescent cold (NiAg). A sulphur test was obtained, apparently due to some admixture.

Analysis of a sample prepared as described above yielded:

SiO_2,	4.56
Pb,	trace.
Ag,	8.38
As,	67.37
Ni,	11.12
Co,	5.13
Fe,	2.64
	99.20

If the SiO_2 is assumed to be present as quartz and the Ag as native silver, we have, by recalculation:

					Approx. ratio.
As,	78.10	÷ 75	1.0413		21
Ni,	12.89	÷ 58.7	.2195		4
Co,	5.95	÷ 59.	.1008	.3749	2
Fe,	3.06	÷ 56.	.0546		1
	100.00				

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This corresponds approximately to a composition RAs_3 in which $R = \frac{4}{7}Ni\ \frac{2}{7}Co\ \frac{1}{7}Fe$.

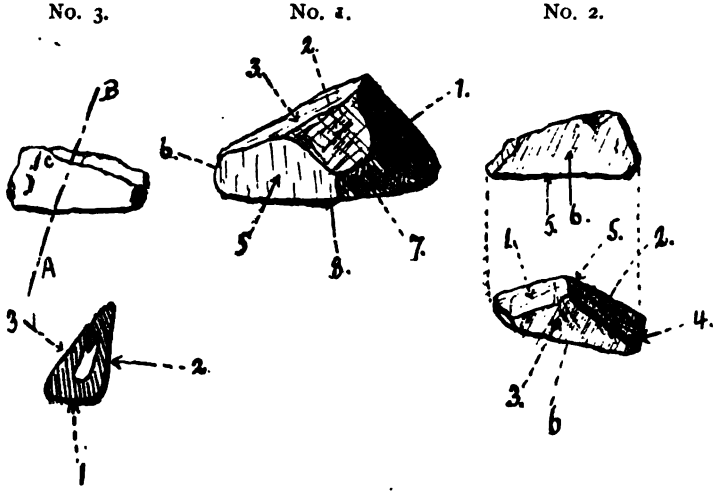
This would be a mineral of the type of skutterudite $CoAs_3$. A mineral with the assumed ratio would have the composition:

As,	78.67
Ni,	12.25
Co,	6.16
Fe,	2.92
	100.00

If further analysis confirms these results, the name NICKEL-SKUTTERUDITE is suggested.

GRAPHITE PRESSURE PSEUDOMORPHS.—BY A. J. MOSES.

The crystallization of graphite is generally conceded to be hexagonal, though the Ersby and Störgard graphite was considered monoclinic by Nordenskiöld. Three specimens of Ceylon graphite sent me by Mr. W. F. Downs of the Joseph Dixon Crucible Co., Jersey City, are polyhedral, and have a certain repetition of angle suggestive of crystallization, yet their lack of symmetry seems to place them with those pseudomorphs which owe their polyhedral



shape to intersecting plates of other minerals, *i.e.*, "pseudomorphous after interstices. One of the specimens (No. 3) was evidently produced by forcing a plate-like fragment into a polyhedral cavity, for it is somewhat hollow and shows the line of the

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overlap across one face. The section illustrates this. The free-hand sketches, approximately full-sized, and the table of angles, in order of size, obtained with the hand goniometer, give a fair idea of the forms:

No. 1. Eight faces.		No. 2. Six faces.		No. 3. Three faces.	
1 ∧ 5	58°	1 ∧ 6	32°	2 ∧ 3	41°
4 ∧ 8	58°	2 ∧ 3	68°	1 ∧ 3	57°
1 ∧ 8	59°	3 ∧ 6	68°	1 ∧ 2	86°
1 ∧ 3	91½°	1 ∧ 5	77°		
3 ∧ 5	98°	5 ∧ 6	98°		
1 ∧ 7	98°	2 ∧ 4	101°		
1 ∧ 4	99°	1 ∧ 2	107°		
3 ∧ 4	106°	1 ∧ 3	112°		
5 ∧ 8	109°	2 ∧ 5	127°		
7 ∧ 8	110°	4 ∧ 6	127°		
1 ∧ 2	111°	4 ∧ 5	144°		
2 ∧ 5	116°				

MAGNETITE PSEUDOMORPHOUS AFTER HEMATITE.—BY A. J. MOSES.

It is worth noting that in the many specimens of the Antwerp, N. Y., ore which are in the School of Mines collection, the hematite has been reduced to magnetite near all surfaces on which either the silicate stilpnomelane (usually considered ferrous) and the ferrous carbonates, ankerite and siderite, have been deposited. This change is especially true of the hematite crystals, but in some instances the reduction has made a crust of magnetic oxide 5 to 6 mm. thick on non-crystallized material.

Magnetite is known to be the associate of the stilpnomelanes of Silesia and Moravia, which are recorded as ferrous; the stilpnomelane of Antwerp alone has been recorded as containing some ferric iron, and as to this the analyses differ; the identity in condition of the associated iron oxide may suggest identity in the state of the iron in the stilpnomelane.

ORTHOCLASE FROM CANADA.—BY B. C. HINMAN.

A fine cleavable feldspar from thirty miles from Buckingham, Ottawa Co., Province of Quebec, yielded:

SiO_2,	65.87
Al_2O_3	19.32
K_2O,	11.78
CaO,	0.64
Na_2O,	2.39
	100.00

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ON TOPAZ FROM JAPAN.—BY W. D. MATTHEW.

The crystals examined were brought to America by Professor Egleston, and are now in the collection of the School of Mines, Columbia College. With the exception of one specimen in a large plate of mica in what seems to be a decomposed pegmatite, they are all loose crystals and mostly more or less worn; they are transparent and colorless or bluish, and show in many cases curious irregularities, either etching figures or growths. The crystals are from two localities, one in the Province of Omi and the other the tin-mines at Yenagari Mino. The latter can be approximately separated by their being more waterworn and generally more wedge-shaped than the others. About 75 crystals from Omi and 25 from the tin-mines were examined.

The faces found were as follows, the nomenclature used being that in the new edition of Dana's *System of Mineralogy:*

Pyramids:

i (223, $\frac{2}{3}$). Not very common, moderately well developed.

u (111, 1). Generally present and well developed.

o (221, 2). Generally present and fairly well developed.

v (121, 2–$\breve{2}$). Occurs in one specimen, fairly well developed, but with rough surface.

Prisms:

m (110, I). Always present and well-developed.

O (560, i–$\breve{\frac{6}{5}}$). Occurs in one specimen, very narrow.

M (230, i–$\breve{\frac{3}{2}}$). Present in about 25 per cent. of the crystals, very narrow.

l (120, i–$\breve{2}$). Always present and well developed. Often striated, alternating with m.

π (250, i–$\breve{\frac{5}{2}}$). In one specimen, very narrow.

– (4·11·0, i–$\breve{\frac{11}{4}}$). In one specimen, very narrow.

g (130, i–$\breve{3}$). Not very common, very narrow.

Pinacoids:

c (001, O). Not uncommon; apt to be associated with pyramids i and u.

b (010, i–$\breve{\imath}$). Quite common, but nearly always very narrow.

a (010, i–$\bar{\imath}$). In one specimen, doubtful.

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Brachydomes:

X (043, $\frac{4}{3}$–$\breve{i}$). Not common; associated with pyramid i.

f (021, 2–$\breve{i}$). Almost always prominent, giving a more or less noticeable wedge shape to the crystals.

y (041, 4–$\breve{i}$). Generally present, modifying f more or less.

FIG. 1.

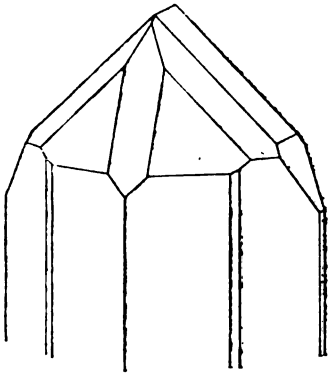


FIG. 2.

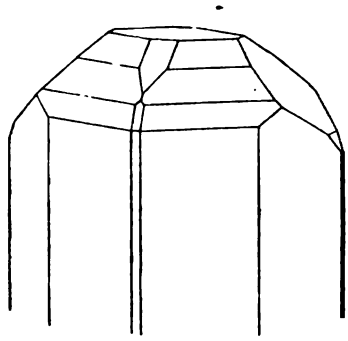


FIG. 3.

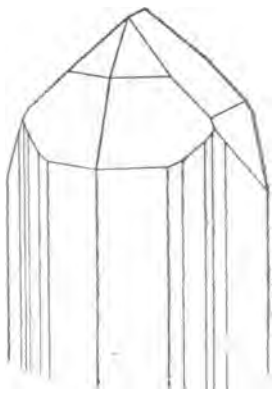
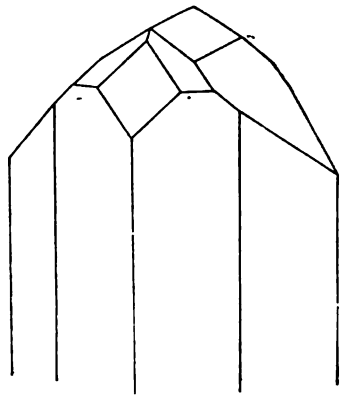


FIG. 4.



Macrodomes:

h (203, $\frac{2}{3}$–$\bar{i}$). Not common; associated with i.

d (201, 2–$\bar{i}$). Generally present and moderately well developed.

The foregoing are all recorded by Dana and Goldschmidt, except one brachy-prism lying between π and g. The following readings were obtained of the angle between this and the prism l:

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8° 45′ 8° 46′ 8° 47′ 20″

As l was a striated face, the readings were taken at the brightest part of the reflection, not at its centre. Less certain determinations gave for the angle between the new face and the prism m the following readings:

27° 54′ 40″ 27° 58′ 40″

The nearest recorded faces are π and g, which give, with the prism l, angles of 6° 17′ 32″ and 11° 10′ 21″ respectively. The face was given the index $\frac{11}{4}$, the readings being probably not very accurate, on account of the striation of l and m; theoretically, its angle should have been 8° 52′ 58″ with l and 27° 36′ 20″ with m.

The figures represent actual Omi crystals, with the faces of the proper proportionate size. No type form is given, the crystals having been selected to illustrate as many as possible of the occurring faces; the following are those shown on each:

Fig. 1.—o, v, m, M, l, b, f, y, d.
Fig. 2.—i, o, u, m, l, c, b, a, f, y, h, d.
Fig. 3:—u, o, m, M, l, π, g, f, y, and the unrecorded face $\infty \breve{P} \frac{11}{4}$.
Fig 4.—u, m, l, X, f, d.

The face l is a little more generally prominent than m; the other vertical faces are rarely large, generally being merely slight modifications of the edges.

Besides the basal cleavage, traces of cleavage parallel to f and d were observed.

The largest crystal in the collection is 119 mm. long (macroaxis) and 85 mm. wide (brachyaxis), and shows the following faces: f, m and l well developed; u, o and d small; X doubtful.

The specimens supposed to be from the tin-mines show the following differences: o and d less developed. Prism faces, except l and m, less common (this may be due to wear). X and c are more common; f much developed at the expense of y (which is much less common), giving the crystals a more noticeable wedge-shape.

Wada* describes and figures topaz crystals occurring in pegmatitic veins in the granites of Otani-yama, in the province of

* "Ueber einege japanische Mineralien," in *Sitzungsber. Naturf. Freunde*, 17 Juni, 1884, pp. 79–86.

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Omi, near Kioto. These are water-clear, yellowish and greenish, of remarkable size, and resemble in form those from the Urals; some also resemble those of the Schneckenstein. He mentions the following faces: i, u, o, M, l, c, b, X, f, y, h and d (nomenclature altered to suit Dana's "System").

ANALYSIS OF THE WATER OF GREAT SALT LAKE, UTAH.

By E. WALLER, Ph D.

The Great Salt Lake of Utah is the largest body of water now remaining in a basin formerly occupied by a large fresh water lake which at one time covered an area of 19,750 square miles (about the area of Lake Huron). This area includes the present alkali deserts, as also the Jordan and Utah lake valley in which Salt Lake City is situated. The outlet of this lake was to the north, its waters finally reaching the Pacific. High up on the flanks of the Wasatch mountains, which limits on the east the valley of the Jordan, and which in former times constituted the eastern shore of the lake, are to be seen the benches of sand and gravel indicating the shore lines of the old lake. The same shore lines are to be seen on the flanks of the Oquirrh range on the west side of the Jordan valley. The peaks of the Oquirrh range formed in times past a chain of islands in the middle of the lake. These shore lines show that at one time the water level was a 1000 feet above the level of the present Salt Lake, and that frequent (comparatively) abrupt lowerings of the lake level occurred, until finally it became too low for the water to run off through its original outlet. The most strongly marked shore line (called the "Provo shore line") is 375 feet above the present Salt Lake, but several intermediate shore lines are visible.

The earliest notes of exploration on the basin of this ancient lake were made by Captain Bonneville in 1833. It may be mentioned that those notes were edited by Washington Irving. Captain Bonneville having been the first to recognize the former existence of this body of water, the name Lake Bonneville has been given to it. A very complete account of the Bonneville basin is

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given in Monograph I. of the U. S. Geological Survey, entitled "Lake Bonneville, by C. K. Gilbert, Washington, 1890."

The area of Great Salt Lake may be put in round numbers at 2000 square miles. During the time that it has been observed, its level has been subject to oscillations which have made considerable differences in its extent, since it is comparatively shallow, and the slope of its shores is very gradual, so that a change of a few feet in its level effects a very considerable change in area. In illustration, a few of the figures may be quoted from the results of Stansbury's survey in 1850 and King's survey in 1868.

	Stansbury (1850).	King (1868).
Area, ...	1750 square miles.	2170 square miles.
Maximum depth, . .	36 feet.	49 feet.
Average depth, . .	13 feet.	18 feet

The tendency since the time of King's survey has been to a contraction of the lake. To all appearances, evaporation goes on more rapidly than water can be supplied by atmospheric precipitation on the region supplying the lake. Its exceeding shallowness is, of course, especially favorable to loss by evaporation, while the annual rainfall in that region is only ten or eleven inches.

Analyses of the water of the lake have been made at different times. The results differ more widely than is ordinarily the case with such observations. This is owing mainly to the following causes: The ratio of water to dissolved salts is no doubt constantly changing with the alteration in volume of the water by evaporation, etc., to which allusion has been made, and such variations are probably considerable at different places at the same time, and even at the same place at different times. With some constituents the water is already near the saturation point, and differences of temperature due to the season are apt to cause differences in composition. The composition of the water is also liable to variations at different places on account of the influx of other water which may be fresh or saline, and in many cases are, no doubt, subterranean (springs). Along the line of fault caused by the upheaval of the Wasatch range, many hot springs, carrying considerable quantities of salts have been found, and it is not unreasonable to suppose that there may be others, the waters from which find their way into the lake without giving any indications of their presence to the observer.

While on a visit to Garfield Beach, which is at the southern end

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of the lake, I secured a quart-bottle full of the water which was brought to the laboratory for analysis. As the date of taking the sample has some importance, it may be here mentioned (August 9, 1892). About 150 feet from the shore. Depth at that point, between 4 and 5 feet.

To one bathing in the water two features are especially noticeable: its excessively salt taste, which, however, is strangely free from the bitter flavor of ordinary sea water, and its high specific gravity. It is practically impossible to sink in the water, and one can float in any position with more of the person out of water than usual. On the other hand, wading through the water waist-deep, or attempting to swim, is very laborious on account of the density, and it is said that in case of high winds the waves are very heavy and strike with unusual force.

The results of the analysis were as follows:

GRAMMES PER LITRE.

Elements and radicals.		Probable combination.	
Na,	75.825	NaCl,	192.860
K,	3.925	K_2SO_4,	8.756
Li,	0.021	Li_2SO_4,	0.166
Mg,	4.844	$MgCl_2$,	15.044
Ca,	2.424	$MgSO_4$,	5.216
Cl,	128.278	$CaSO_4$,	8.240
SO_3,	12.522	Fe_2O_3 and Al_2O_3,	0.004
O in sulphates,	2.494	SiO_2,	0.018
Fe_2O_3 and Al_2O_3,	0.004	Surplus SO_3,	0.051
SiO_2	0.018		230.355
Bo_2O_3,	Trace,	Total solids by evaporation,	238.12
Br,*	Faint trace.		

The discrepancy between the results by evaporation and by calculation is probably due to the hygroscopic character of many of the salts present. It required especial care and quick weighings to obtain anything like constant weights.

A duplicate determination showed Total solids 237.925 grammes per litre.

The water was absolutely neutral to test-paper, and the surplus SO_3 (0.051) gramme might perhaps be attributed to the difficulty of obtaining a pure precipitate of $BaSO_4$ in the presence of such large quantities of interfering salts. A duplicate determination

* Since this was written an approximate determination showed about 0.01 gm. Br per litre.

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gave a higher figure for SO_3, and Prof. O. D. Allen's report of a sample of the water analyzed in 1869 mentions an "excess of chlorine" 0.9 part per 1000, while that of H. Basset in 1873 gives "excess of chlorine" 2 parts per 1000.

It may be of interest to reproduce the table given by Gilbert recording the previous analyses of this water, appending also the above results where they contrast.

Parts per Thousand.

	I.	II.	III.	IV.	V.	VI.
Date	1850.	Sum'r, 1869.	Aug., 1873.	Dec., 1885.	Aug., 1889.	Aug., 1892.
Analyst	L. D. Gale.	O. D. Allen.	H. Bassett.	Talmadge.	Talmadge.	E. Waller.
Specific Gravity	1.170	(1.111)	1.102	1.122	1.157	1.156
Cl	124.5	84.0	73.6	90.7	110.5	128.278
SO_4	12.4	9.9	8.8	13.1	11.7	14.964
Na	85.3	49.6	38.3	58.2	65.3	75 825
K	.....	2.4	9.9	1.9	2.1	3.925
Ca	Trace.	0.2	0.6	0.4	0.8	2.424
Mg	0.6	3.8	3.0	2.9	5.1	4.844
Bo_2O_3	.....	Trace.	.....	.....	.....	Trace.
P_2O_5	.....	Trace.	.....	.....	.....	.....
Total	222.8	149.9	134.2	167.2	195.5	.....

Probable Combinations.

	I. (1850.)	II. (1869.)	III. (1873.)	IV. (1885.)	V. (1889.)	VI. (1892.)
NaCl	202.0	118.6	88.5	135.9	157.4	192.860
KCl	.....	.....	18.9	.....	.....	.....
$MgCl_2$	2.5	14.9	11.9	11.3	20.1	15.043
Na_2SO_4	18.3	9.3	10.9	14.2	10.5	.....
K_2SO_4	.....	5.3	.....	4.3	4 7	8.756
$MgSO_4$	.....	.....	.....	.....	.....	5.216
$CaSO_4$	.....	0.9	2.0	1.5	2.8	8.240
Cl (excess)	.....	0.9	2.0	.....	.....	0.045
	222.8	149.9	134.2	167.2	195.5	.....

References.—I. Stansbury's Report. "Expedition to the Great Salt Lake," p. 419.

II. Survey of the Fortieth Parallel. *Systematic Geology*, Vol. I., p. 502, and *Descriptive Geology*, Vol. II., p. 433.

III. Collected by Dr. Marcet. H. Bassett, *Chemical News*, XXVIII., p. 236.

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IV. and V., J. E. Talmadge, "*Science*," XIV. (1889), p. 445.

As has been suggested by Gilbert, the localities at which the samples were taken were not noted in most of these cases, and local influences, as well as those due to season, may perhaps account for some of the discordant results obtained; nevertheless, the inevitable inference from an examination of these figures, in the light of the known facts regarding changes in the level of the lake, must be that the average amount of the salts, and their relative proportions are constantly changing.

In my own calculation (made in accordance with the rules formulated by Fresenius), no Na_2SO_4 is made to appear; yet it is well known that in the winter time, when the temperature of the water is brought down to 20° F. or below, large amounts of sodium sulphate separate from the water. It might, perhaps, be argued that it was not until the conditions of temperature favor, that an interchange of acid and basic radicals would occur to cause the formation of Na_2SO_4.

As regards the probable period which has elapsed since Lake Bonneville was in existence, Gilbert gives an interesting calculation, indicating that if the Great Salt Lake received only the salts contributed by the Bear River and the Jordan (its present tributaries) it would require 34,000 years to attain the saltness found in 1869, but that if allowance is made for the contributions of saline matter from littoral salt springs, some 10,000 years less would have been consumed. The variations in composition of the salts in the water, as judged from the list of analyses quoted, suggest that such calculations leave a wide margin for guess-work. Gilbert also says (p. 258): "There are certain soluble but very rare substances, such as the compounds of boron, lithium, iodine and bromine, which tend to accumulate in inland lakes of great antiquity, and have come to be regarded as the diagnostic characters of age. Only one of these (boron) has been detected in the water of Great Salt Lake, and that one is not found in measurable quantity." "The conclusion that the brine is recently accumulated accords with the facts derived from the Bonneville history, for at the time of the outflow the salts stored in the lake must have been discharged beyond the limits of the basin."

The argument, so far as it is based upon the absence of the elements enumerated, seems to he defective, Mr. Gilbert apparently having overlooked reference in Kings's report (Survey of the 40th

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Parallel, Vol. I., p. 495), to the detection of lithium by R. W. Woodward in many of the evaporation products of Lake Bonneville, also in the same report (Vol. II., p. 434), Prof. O. D. Allen's note as to the detection of traces of lithium and bromine as well as boric acid in the Salt Lake water itself. In my sample the salts left on evaporating only 10 c.c. of the water showed the lithium line in the spectroscope distinctly, and from the way in which Prof. Allen speaks of the tests upon the water for that element, his sample apparently contained as much as my own. The reaction for bromine was quite faint, but doubtless in a sufficient quantity of the water, both bromine and iodine might be found in weighable quantities, probably in as large proportion as in many waters coming from "older" sources.

It must not be overlooked that the proportions of salts found are reported in parts per thousand, whereas in most analyses of mineral waters the salts are reported in parts per hundred thousand or in grains per gallon (parts per 58,318), and that the amount of lithia salt found in this analysis is equal to, if not greater than the largest amount found in any one of the Saratoga mineral waters.

By way of illustration, the grains per gallon of the various elements and acid radicals determined in the Salt Lake water and in the Saratoga Hathorn Spring water may be contrasted.

GRAINS PER GALLON.

	Great Salt Lake.	Saratoga. Hathorn.
Na_2	4421.962	202.058
K,	228.898	5.024
Li,	1.225	1.179
Mg,	282.492	29.008
Ca,	141.363	42.135
Ba,	.....	0.919
Iron and alumina,	0.233	0.587
Cl,	7480.916	314.037
Br,	Trace?	1.188
I,	?	0.166
SO_3	730.258	Trace.
CO_2 (in bicarbonates),	.....	209.856
H_2O (in bicarbonates),	.....	42.929
SiO_2	1.050	1.260
O in bases,	145 445	38 055
Total,	13433.842	888.403
Total solids by evaporation,	13886.682	740.550

Of the Salt Lake water, barely a quart was available for analysis; of the Hathorn water, several gallons.

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ABSTRACTS.

Analytical Chemistry, by E. Waller, Ph.D.

Azolitmin Paper. Dietal (*Pharm. Zeit.*, xxxvii., 7). Digest 50 grammes of litmus for 12 hours with 1 litre of water. Decant and repeat the operation with a second litre of water. Mix the united filtrates with 100 grammes of sand, add HCl until all CO_2 is expelled. Evaporate to dryness, and heat to expel the HCl. Grind the residue to powder, and wash well, first with hot, then with cold water, until the filtrate is no longer colored. Dry finally between blotting paper. To prepare the paper, treat 10 grammes of the azolitmin sand with 100 grammes hot water and 15 grammes NH_4Cl. Allow to stand for some time, filter, and soak pieces of filter paper in the solution. On drying spontaneously a red violet color is obtained which is sensitive to either acids or alkalies.

Standardizing Acidimetric and Alkalimetric Solutions. Parsons (*J. Anal. and App. Chem.*, vi., 372 *et seq.*), concludes from his experiments that the most accurate method of standardizing is with potassium tetroxalate (volumetrically). Of the gravimetric methods the determination (of standard HCl) by precipitation as AgCl is given the preference. The tetroxalate as usually obtained, frequently contains more or less acid (bi) oxalate. Using an excess of oxalic acid for the first crystallization and keeping the solution hot for an hour or more before cooling to crystallize out, are especially advised. No material gain or loss by exposure to ordinary conditions, or by drying over sulphuric acid was detected. Litmus was found to be the best indicator with it. The point taken is the *distinct appearance of the blue* (adding an alkaline solution from the burette). Cochineal, methyl orange and turmeric, are unsatisfactory. Acid potassium tartrate, strongly recommended by Bornträger (*Vid.* Quarterly, xiii., 175), was found to be more difficult of preparation, as it tends to retain an excess of acid. Bornträger's directions are not sufficient for obtaining a salt of the necessary purity.

Lime and Magnesia in Gun Cotton. Schjerning (*Zts. Anal. Chem.*, xxxi., 283). Weigh out 3 to 5 grammes of the cotton, wet down with a mixture of equal parts ether and alcohol, saturated with paraffin, add one-fourth the volume of water, and introduce a few pieces of paraffin. Ignite the ether vapors, moving the dish about so that the cotton is soaked with the paraffin. Finally incinerate completely to ash over a strong flame, and weigh total ash (B per cent). Then heat with an excess of tenth normal HCl to 90° C. Cool—add a little pure NaCl, and a few drops of litmus solution and then render perceptibly alkaline with tenth normal soda. Filter off and weigh "impurities" (C per cent)., consisting of Fe_2O_3, Al_2O_3 and SiO_2 and titrate back with tenth normal acid. Representing by A the c.c. of tenth normal acid neutralized by the bases in 100 grammes of the cotton.

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Per cent. MgO = [A 0.0028 — (B—C)] 2.5.
Per cent. CaO = [(B—C) — A 0 002] 3.5.

Qualitative Test for Strontium. McElroy and Bigelow (*J. Anal. and App. Chem.*, vi., 266. Evaporate the HCl solution of $CaCO_3$ and $SrCO_3$ on the water bath to crystallization take up with acetone and water (1 : 1) and add K_2CrO_4 solution in a similar solution of acetone to which a drop of ammonia has been added. Under these conditions anhydrous $SrCrO_4$ is completely precipitated.

Barium in Presence of Calcium and Magnesium. Mar (*Am. Jour Sci.*, xliii., June, 1892). $BaCl_2$ is soluble to the extent of about 1 : 20,000 in pure concentrated HCl. The solubility increases rapidly by dilution. In conc. HCl containing 10 per cent. of ether its solubility is about 1 : 120,000. $CaCl_2$ and $MgCl_2$ are however soluble. A separation can therefore be effected by converting a mixture of the three into chlorides, which are dissolved in the least possible quantity of boiling water. (As the most of the experiments were conducted on lots of about 0.5 grammes $BaCl_2$, $2H_2O$, the amount convenient for the operation should presumably be not over this), 25 c.c. conc. HCl are then added drop by drop, and when the solution is cool, 5 c.c. of absolute ether. Allow to stand a few minutes, filter through asbestos felt in a Gooch crucible, and wash with conc. HCl containing about 10 per cent. of ether. Dry at 150–200° C and weigh $BaCl_2$.

Precipitation of Aluminum Phosphate. Glaser (*Fres. Zts. Anal. Chem.*, xxxi., 383). Precipitation with alkaline acetate at the temperature of boiling afforded a mixture of neutral and basic salt, containing 46.6 per cent. Al_2O_3. If the temperature was brought only to 70° C. and not allowed to pass that point the composition of the precipitate was $AlPO_4$.

Precipitation with ammonia left both alumina and phosphoric acid in solution.

A solution containing calcium, aluminum and ferric phosphate should be thus managed for determination of Fe_2O_3 and Al_2O_3: the solution which should contain no free Cl, is *nearly* neutralized with ammonia, the neutralization being controlled by the indications afforded by a few drops of meythl orange in the solution. Then add a few c.c. of sodium or ammonium acetate solution (preferably the latter), and heat to 70° C. to effect precipitation of iron and alumina phosphates. Dissolve in HCl and reprecipitate as before after addition of a little Na_2HPO_4. Filter, wash, ignite and weigh, cover with pure Na_2CO_3, fuse ten minutes over the blast. Leach out the melt with water, filter and wash hot. The insoluble Fe_2O_3 may be dissolved in HCl and precipitated by ammonia for weighing, or the solution may be acidified and the above method repeated for determination of Al_2O_3 as $AlPO_4$.

If the amount of Na_2CO_3 used in the fusion is relatively small, the solution on cooling deposits some basic phosphate ($Al_2P_2O_7$).

Separating Ferric Oxide from Alumina. Beilstein and Luther (*Fres. Zts. Anal. Chem.*, xxxi., 206). Dissolve the precipitated hydrates in HNO_3 and evaporate until acid vapors ceased to be evolved. Then cover with water and boil for 10 minutes. Cool—add 2 to 3 c.c. of a

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10 per cent. solution of $(NH_4)_2SO_4$. Stir in, and filter off the basic ferric nitrate. Wash (first by decantation), with cold dilute NH_4NO_3 solution, finishing with the same solution hot, Alumina only passes into the filtrate.

Determination of Zinc in Ores. A. H. Low (For full description *vid.* this number, p. 40). Applicable to plumbiferous ores containing zinc. The ore is decomposed by HNO_3 containing $KClO_3$ in solution, which by evaporation causes the separation of Mn as MnO_2. The residue is taken up with ammonia and NH_4Cl, and filtered, the solution acidified with HCl, and the zinc titrated with standard ferrocyanide solution.

Qualitatitive Detection of Nickel and Cobalt. Hambly (*Chem. News*, lxv., 289). The cyanide method is thus modified: After separating the mixed sulphides by the action of cold dilute HCl, and testing with a bead, dissolve in HCl and $KClO_3$, boil out the excess of Cl. and evaporate off the excess of acid. To the neutral solution add slight excess of KCy, make alkaline with NaOH, add bromine water, heat gently, allow to stand and filter off Ni_2O_3. If only traces of Co are to be expected, acidify with H_2SO_4, evaporate nearly to dryness *under the hood*, dilute and test the solution with $(NH_4)_2S$, etc.

Detection of Small Amounts of Lead in Presence of Copper aud Iron. Teed (*Analyst*, xvii., 142). Add a few c.c. of ammonia, then a little KCy and then ammonium sulphide. The iron is converted to ferro-or ferricyanide. CuS is soluble in KCy, and only PbS remains to give the characteristic brownish or blackish tint. The method is applicable when substances are present which reduce alkaline chromate.

Analysis of Galena and of Lead Sulphate. Benedikt (*Ch m. Ztg.*, xvi., 43). If galena is attacked by HNO_3 some $PbSO_4$ remains with the gangue. The author has found that sulphates are more or less readily converted to iodides by treatment with HI. Free H_2SO_4 is converted to H_2S.

The method proposed is: treat the finely pulverized sample with a few c.c. of HI (Sp. Gr. 1.7) in a dish (covered if the action is violent) on the water bath. After a short time, cool, add dilute HNO_3, and warm up which affords Pb $(NO_3)_2$ with separation of I. The reaction for $PbSO_4$ is given as $PbSO_4 + 10HI = PbI_2 + 4H_2O + H_2S + 4I_2$.

Determining Lead in Ores, Etc. (Von Schultz and Low). The method consists in converting all the lead to sulphate, which is dissolved in hot NH_4Cl solution and the metal precipitated for weighing by sheet aluminum. The detail is as follows: Decompose 1 gramme of the ore in a flask by use of 10 c.c. each of conc. H_2SO_4 and HNO_3. Heat until all HNO_3 is expelled. Cool and add 10 c.c. diluted H_2SO_4 (1 : 9), then about 2 grammes Rochelle salt. When this is dissolved, add 40 c.c. water and boil. Allow to stand and settle for a few minutes, then filter and wash with diluted H_2SO_4. Rinse all solid particles from the flask into the filter by means of the diluted H_2SO_4. Now put into the flask three strips of Al foil one-sixteenth inch thick by 5/8 by 1 3/4 inches. Set the funnel over the flask and dissolve the $PbSO_4$ back into it by boiling

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solution of NH_4Cl (saturated in the cold). Wash well with the same. Boil for five minutes. Agitate, fill the flask with cold water, wash by decantation and invert over a porcelain capsule, into which the Pb and Al are allowed to settle. Remove the flask in such a way that the metals are not lost. Remove the Al strips, rubbing off any adhering lead *under water*. Decant the water as closely as possible, and press the lead into a more or less coherent sheet by an agate pestle. Wash a few times with water, finally with alcohol dry and weigh. If Sb is absent, the Rochelle salt may be omitted, and less acid is required in effecting solution. Commercial Al, which contains Si, is liable to give high results. If made by the sodium process, this difficulty is avoided. The strips may be used again and again until they become too thin and light to be manageable. A deduction of 3 per cent. from the result gives about the percentage obtained by fire assays on the same sample.

Bismuth in Refinery Slag. Hampe (*Chem. Ztg.*, xv., 410). Digest 1 gramme for some time with 15 c.c. HNO_3 in a platinum dish. Then add 10 c.c. HFl to decompose the silicates. Then add a few drops H_2SO_4 and evaporate to dryness. Dissolve in HNO_3, filter and neutralize with ammonia. Add ammonium carbonate, boil and filter. The precipitate is dissolved in nitric acid and precipitated by H_2S. The mixed PbS and Bi_2S_3 are dissolved in HNO_3, the solution precipitated with ammonium carbonate, and that precipitate treated with HCl and evaporated to dryness. Considerable quantities of hot water will then extract $PbCl_2$, leaving BiOCl, which may be converted to oxide for weighing in the usual manner (solution in HNO_3 and precipitation by $(NH_4)_2CO_3$).

Volumetric for Mercury. Namias (*Chem. News*, lxvi. 90). The mercury must be in the form of $HgCl_2$. It is then titrated with a standardized solution of $SnCl_2$, added gradually, until a drop of the solution gives a blue spot on a paper freshly saturated with Na_2MoO_4 solution. This marks the complete conversion to Hg_2Cl_2. $SnCl_2$ solution 2 to 3 grammes per litre. Free HCl should be about 0.5 c.c. in 50 c.c. of the liquid titrated.

Gold and Silver in Copper Mattes, Etc. Whitehead (*J. Anal. and App. Chem.*, vi., 262). In determining small amounts especially, the losses by scorification assay are sometimes serious. The method proposed is as follows: Dissolve 1 to 4 A.T. in a large beaker by gradual addition of HNO_3; heat off the red fumes, stir in 50 grammes $Pb(C_2H_3O_2)_2$, and then add 1 c.c. dilute H_2SO_4 and allow it to settle. The Pb SO_4 carries with it the gold, which otherwise is so finely divided as to be in danger of being lost. Filter and scorify the precipitate along with the ash of the paper with some test-lead—cupel for gold.

Dilute the filtrate to 1000 c.c., divide in halves, and add to each (cold) a saturated solution of NaBr so long as a precipitate forms. Filter and wash with cold water until all Cu has been removed. Dry and brush the precipitates from the paper into small crucibles, mix in three times the weight of Na_2CO_3 and some flour or other reducing agent; cover with borax glass and fuse for lead buttons. Cupel these buttons to obtain the silver.

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Arsenic Tests. Schmidt (*Chem. News*, lxvi., 71 and 83) quotes Fresenius's condemnation of gravimetric processes founded on the volatility of AsH_3 or SbH_3. His investigations indicate that when As is present as arsenide in the substance tested (in a Marsh apparatus) it escapes entirely as AsH_3, but when in some oxidized combination, such is not the case. It may, however, be *completely* driven over as AsH_3 by adding an HCl solution of $SnCl_2$ after the evolution of gas became sluggish.

Assay of Tin Ores by the Use of KCy. Rennie and Derrick (*J. S. C. I.*, xi., 662). The ore should be pulverized. If fairly rich, the sample should be all passed through a 60 sieve; if of low grade and containing much iron, a 90 sieve should be used. Two hundred and fifty grains are then boiled for half an hour with 3-oz. HCl and ½-oz. HNO_3, after which it is washed by decantation. Tungsten, if present, is dissolved out by ammonia. The silica is then removed by careful vanning, the details of which are described. The resulting purified oxide (SnO_2) is dried and weighed. Take a fine-grained clay crucible, 3 inches high and and 2½ inches diameter; ram into the bottom a layer of *dry* pulverized KCy; then introduce 50 grains of the purified oxide mixed with 300 grains of dry KCy, and cover with dry cyanide. Cover the crucible, and introduce into a muffle previously heated to redness. Keep at a cherry-red heat for 10 minutes, then shake gently to settle the reduced metal, and increase the heat to bright-red for five minutes. Withdraw, cool, fill the crucible gradually with hot water to dissolve out the slag, take out the button, and any prills that may have been formed, wash, dry and weigh.

One must make certain that the KCy is pure, finely powdered and thoroughly dry. It is recommended that this, as well as the ore, crucible spatula, etc., be dried perfectly by heating. Crucibles with a rough interior surface are to be avoided. Fusion should take place quickly after insertion into the muffle. At the end of the fusion a globule of green silicious slag will be observed to rise to the surface. This marks the end of the operation.

Vanadic Acid. Rosenheim and Freidheim (*Zts f. anorg. Chem.*, 1, 313). In a sulphuric acid solution, vanadic acid acts upon oxalic acid thus: $V_2O_5 + H_2C_2O_4 = V_2O_4 + H_2O + CO_2$ or 100 parts V_2O_5 correspond to 48.246 parts CO_2. The escaping CO_2 may be determined (preferably by absorption). The reaction is adapted for the determination of V_2O_5 in presence of phosphoric, tungstic or molybdic acids. The proportion of reagents recommended are equal volumes of 10 per cent. H_2SO_4 and of a saturated solution of $H_2C_2O_4$ with the solution to be analyzed.

Sulphur in Iron and Steel. Babbitt (*J. Anal. and App. Chem.*, vi., 301) describes the Wiborgh method (evolution and comparing tint imparted to a cloth soaked in Cd $(C_2H_3O_2)_2$ solution) which is used in most works in Sweden. Clymer (*ib.* 319) gives a list of several determinations made on the same sample by expert iron chemists, in which the results varied from 0.005 to 0.024 per cent. The differences did not seem to be due to the methods employed but to the manipulation details. The sources of error in the aqua regia method seem to be: 1. Evaporating too far for the separation of SiO_2, etc., so as to leave some insoluble basic

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ferric sulphate. 2. Precipitating $BaSO_4$ in too acid a solution (which retards the precipitation) and not allowing sufficient time. 3. Precipitating $BaSO_4$ in a solution too nearly neutral, allowing contamination with iron. The use of ammonia to neutralize the excess of acid and allowing to stand for fourteen hours to precipitate are recommended.

Sulphur in Iron. Eastwick (*J. Anal. and App. Chem.*, vi., 245) recommends an evolution method in which the H_2S, H, etc., are passed through an ammoniacal solution of $CdCl_2$. A small bottle is interposed between the generating and receiving flasks to intercept any HCl which may boil out of the iron solution. When the first stage of the process is over, the Cd solution is strongly acidified with HCl, and at once titrated with standard iodine solution.

Sulphur Determination. Treadwell (*Berichte*, xxv., 2377.) Heating the powdered mineral with pulverized iron, and then evolving the S as H_2S by treatment with HCl with suitable precautions, will afford all the sulphur whether present in the original as sulphide or sulphate.

Sulphur in sulphides or in the elemental form, is completely converted to H_2S by treating the material with tin and HCl in an atmosphere of hydrogen. The method is applicable in the presence of As or Sb, where the evolved gas is passed into ammoniacal H_2O_2, and the barium precipitation follows. Zinc instead of tin, as recommended by Klobekow, did not give satisfactory results.

Sulphur in Coals and Organic Substances. Hempel (*Zts. angew. Chem.*, 1892, 393.) A weighed quantity of the substance is burned in an atmosphere of oxygen (10 litres) in a small platinum gauze basket, the combustion being started and maintained by a spiral of platinum wire imbedded in the substance, which is made to glow by the passage of an electric current. The interior of the combustion vessel may be afterward rinsed out and the solution precipitated with $BaCl_2$ as usual. The test analyses compared with results by Eschka's method show results slightly higher. (The use of a rubber stopper for closing the combustion vessel may account for this.—*Abs.*)

Sulphur by Eschka's Method. Hundeshagen (*J. Anal. and App. Chem.*, vi., 385) finds that when Na_2CO_3 is used, some loss of H_2S occurs, which is not the case if K_2CO_3 is used instead. The mixture recommended is 2 parts MgO with 1 part calcined K_2CO_3, of which 2 grms. are used per grm. of coal.

Volumetric for Sulphuric Acid. Stolle recently proposed a method similar to that of Andrews (*vide* QUARTERLY, xi., 378). Precipitation by use of a standard solution of $BaCrO_4$ in HCl, neutralizing with ammonia, which precipitates the excess of $BaCrO_4$, leaving H_2CrO_4 in the solution corresponding in amount to the $BaSO_4$ precipitated. By Andrew's method this H_2CrO_4 was determined by titration with standard $Na_2S_2O_3$, by Stolle's method with standard ferrous solution. Von Asboth (*Chemiker Zeitung*, xvi., 922) finds it defective, since it is impossible to keep for any length of time a solution of $BaCrO_4$ in HCl without gradual evolution of Cl resulting from reaction of the chromate upon the HCl.

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Barium Sulphate Precipitate. M. Ripper (*Zts. angew. Chem.*, 1892, p. 552) after igniting this precipitate restores $BaSO_4$ from the BaS which may have formed, by adding bromine water so long as it is decolorized, drying and igniting again. Previous to the second ignition the precipitate may be warmed with a few drops of HCl, which is decanted off through a small filter to remove salts carried down in the precipitation.

Phosphorus in Iron. Rothberg and Auchinvole (*J. Anal. and App. Chem.*, vi., 244) describes their method which differs only in a few details from those described by Manby and Handy (*vide* QUARTERLY, xiii., 289 and 387) acidimetric titration of the "yellow precipitate." The remark is made that as the compound formed by dissolving the "yellow precipitate" in caustic soda is very volatile, it is essential that the titration be made promptly.

Chlorine in Electrolyzed Solutions. L. M. Norton (*Technology Quarterly*, Dec., '91). The electrolytic action upon aqueous solutions containing alkaline chloride is to afford at ordinary temperatures hypochlorite and chlorate besides chloride. Raising the temperature to 50–55° C. gives practically only chloride and chlorate. Hypochlorite is determined by the ordinary arsenite titration. In an aliquot portion of the solution from this operation the Cl as chloride may be determined by the $AgNO_3$ titration. Deduct the amount present as hypochlorite, and the remainder is calculated as chloride. For total Cl (which by calculation will give Cl as chlorate) complete reduction to chloride and subsequent titration with $AgNO_3$ is the most convenient. The best reducing agent was found to be SO_2. The solution is acidified with HNO_3 and boiled for a few minutes. The solution being then acid the addition of an excess of standard $AgNO_3$ and titrating back with sulphocyanate (Volhard's method) is preferable.

Nitrogen in Coal Gas. New (*J. S. C. I.*, xi., 415). The majority of the bases, and certain hydrocarbons, such as benzine, xylene, etc., are first removed by passing the gas through strong H_2SO_4 (Sp. Gr. 185). Then the whole of the remaining hydrocarbons are converted into CO_2 and H_2O by passing the gas over red hot CuO. From the resulting mixture of CO_2 and N the former is absorbed by NaOH, and the volume of the latter may be determined. The apparatus is described in detail.

Determination of Nitrogen in Nitrates. Arnold and Wedemeyer (*Fres. Zts. Anal. Chem.*, xxxi., 388) find that Boyer's method-combustion with S, CaC_2O_4, and soda lime (*vide* QUARTERLY, xiii., 181) gives results which are altogether erroneous.

A summary of the conclusions is given as follows:

I. Varying amounts of soda-lime, sodium formate and Mg powder. With the substances tried, only one third to one-fourth of the N was obtained as NH_3.

II. Varying amounts of formate and soda-lime, also of oxalate and soda-lime. Results as in I.

III. Varying amounts of soda-lime, formate, thiosulphate and oxalate. Results always 1 to 2 per cent. low.

IV. Varying amounts of soda-lime, formate, and thiosulphate containing water of crystallization.

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Results satisfactory. The best proportions were found to be equal parts of sodium formate, soda-lime and crystallized thiosulphate with 2 parts dry $Na_2S_2O_3$. The combustion can be rapidly carried through (25 to 30 minutes).

The method is not adapted for the analysis of nitro compounds, nitrites, or pyridin and chinoline nitrates.

Determining Nitrates and Nitrites. Ulsch (*Fres. Zts. Anal. Chem.*, xxxi., 392) reports a series of results obtained by measuring the deficit in volume of hydrogen obtained when the acid solution is made to act upon a copper-iron couple. Three gms. of pulverized iron are placed in the decomposing flask which is then connected with the azotometer; an apparatus of special form (previously described), is used. After filling the flask with hydrogen, and precipitating some copper upon the iron by the use of of 2 c.c. of a solution containing 100 gms. crystallized $CuSO_4$ and 30 c.c. conc. H_2SO_4 per litre and taking suitable precautions, the solution to be tested is run into the flask, with 20 c.c. N/10 H_2SO_4 and the evolution of gas allowed to take place *in the cold.* The results quoted seem to indicate that the method is serviceable in water analysis. Chlorides do not interfere, free HCl does.

Quantitative Determination of Nitrites. Grossman (*Chem Zig.*, xvi., 818). About 3 gms. of the salt are dissolved in 200 c.c. of water, an excess of normal sulphuric acid is added, and the mixture boiled until no more NO escapes. The reaction is: $3NaNO_2 + H_2SO_4 = Na_2SO_4 + NaNO_3 + 2NO + H_2O$. The solution is then titrated back with alkali. Each c.c. of acid neutralized by the samples indicates—not the equivalent (69), but 1½ equivalents (103.5).

Analysis of Nitro Explosives. Sanford (*J. Anal. and App. Chem.*, vi., 311). *Dynamite.* Dry 10 grammes over $CaCl_2$ for 6 or 8 days in a desiccator. The loss-moisture is usually under 1 per cent. Extract in a Soxhlet or in an Erlenmeyer flask and weigh the Kieselguhr. The nitro-glycerine is determined by difference as it is too volatile for a direct determination.

Gelatin dynamite. Determine moisture as before. Extract with ether to remove nitro-glycerine, dry at 40° and weigh. Extract them with ether-alcohol to remove gun cotton. The residue consists of KNO_3, possibly other salts, wood pulp and insoluble or non-nitrated cotton. Dry at 40° and weigh.

Another method is to extract first with ether alcohol, and in the solution to precipitate nitro-cellulose by adding chloroform in excess. The first precipitate always carries some nitro-glycerine with it. Redissolve and reprecipitate.

The residue in the case of blasting gelatine is usually Na_2CO_3. In gelignite, etc., it may contain wood pulp, KNO_3, etc. Extract the soluble salts with water, washing very thoroughly. Dry the insoluble pulp, etc., at 40° and weigh. Evaporate the washings to dryness and weigh. Evaporate the washings to dryness and weigh. If the salts are a mixture of Na_2CO_4 and KNO_3, moisten with HNO_3, dry and weigh again, and calculate Na_2CO_3 from the increase in weight.

Nitro-glycerine, as before, is determined by difference.

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Gun cotton. Dry 1000 grammes (in a paper tray) at 100° to constant weight. The moisture in "wet cotton" is usually 20 to 30 per cent.

Solubility test. Expose 5 grammes of the dried sample to the air for 2 hours, and then extract by two successive digestions with ether-alcohol in an Erlenmeyer flask (250 c.c. each time). Filter, etc. Dry at 100° and weigh insoluble and unconverted cotton.

Non-nitrated (unconverted) cotton. Boil 5 grammes of the dried sample with a saturated solution of NaHS. Let stand 48 hours and filter or decant, boil with fresh NaHS, filter dry and weigh. Ignite and deduct ash. The result obtained by this deducted from the preceding, gives insoluble cotton as distinguished from non-nitrated.

Alkalinity. Digest 5 grammes with 20 c.c. quarter normal HCl diluted to 250 c.c. Shake frequently, wash until the washings are no longer acid, and titrate back.

Nitrogen. Use a Lunge nitrometer. Dissolve 0.6 gramme gun cotton or 0.1 to 0.3 gramme nitro-glycerine in 10 c.c. conc. H_2SO_4. Introduce into the nitrometer, rinsing in with conc. H_2SO_4. Shake the measuring tube for ten minutes, let stand, equalize the pressure and read off the volume of NO. Correct for temperature, and calculate. Hexa-nitro contains theoretically 14.14 per cent. N, penta-nitro 11.11 and tetra-nitro 6.76. The two last are in collodion cotton.

Control-Test for the Bessemer and Other Processes. Tropenas and Wells (*J. S. C. I.*, xi., 636), have patented a method for this purpose, depending upon what they assert to be a fact; viz., that the percentage of CO_2 in the converter-gases at any given time during the "blow" maintains a perfectly definite relation with the percentage of carbon in the metal at the time. By passing a definite quantity of the gases through a solution of lime-water of known strength with a suitable indicator, the proportion of carbon in the metal may be determined in 10 to 20 seconds.

Slag in Wrought-Iron. Barrows and Turner (*J. Lond. Chem. Soc.*, lxi., 551). The chlorine method as described by Blair (*Chemical Analysis of Iron*, p. 71), gave low and irregular results. Both slags and ores containing ferrous iron afforded sublimates of ferric chloride at a very low red heat, one-third of the iron volatilizing as chloride, the decomposition apparently being $3FeO = Fe_2O_3 + Fe$. Ferric oxide volatilized as chloride only slowly on heating to a high temperature. The combined effect of a high heat and Cl gas upon ferrous compounds was to afford less $Fe_2Cl_64FeO = Fe_3O_4 + Fe$. Results on dissolving the iron by repeated treatments with a mixture of $CuSO_4$ and NaCl (*vid. Chem. News*, lii., 16) gave more satisfactory results.

Examining Hand-Writing (Inks). Robertson and Hoffman (*Chem. News*, lxvi., 167). The authors draw lines across the letters, etc., with quill pens dipped in the following solutions of reagents, and note the effects, using a microscope if necessary: 1. 3 per cent. $H_2C_2O_4$. 2. 10 per cent. $H_3C_6H_5O_7$. 3. 2 per cent. chloride of lime. 4. 1 part $SnCl_2$, 1 part HCl and 10 parts H_2O. 5. 15 per cent. H_2SO_4. 6. 10 per cent. HCl. 7. 20 per cent. HNO_3. 8. Saturated SO_2. 9. 4 per cent. $AuCl_3$. 10. 1 part K_4FeCy_6, 1 part HCl and 10 parts H_2O. 11. 1 part $Na_2S_2O_3$, 1 part NH_3 and 10 parts H_2O. 12. 4 per cent. NaOH.

A table of the effects on different inks is given.

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METALLURGY, BY JOSEPH STRUTHERS.

FUEL. PRODUCER GAS.—(*American Manufacturer and Iron World*, Nov. 4, 1892.)—The following table is given, quoting Naumann as authority, on the relative theoretical value of producer gas as made by aid of air, water, steam and carbon di-oxide.

			Water Producer Gas.		Carbon Dioxide.
	Water Gas.	Producer Gas.	From Spray.	From Steam	Producer Gas.
Hydrogen, per ct. by volume	50.	.....	17.2	21.1	.....
Carbon monoxide, per cent. by volume.....	50.	34.3	39.7	40.9	57.1
Nitrogen, per ct. by volume	.....	65.7	43.1	38.	42.9
	100.	100.	100.	100.	100.
Heat liberated per litre on combustion (calories).....	2.812	1.044	1.652	1.790	1 739
Temperature of combustion..	2.830° C.	1.904° C.	2.356° C.	2.431° C.	2.449° C.

BLAST FURNACE PRACTICE. BLOWING IN OF A COKE-FURNACE.—*American Manufacturer and Iron World* (Nov. 4, 1892) gives a description by J. S. Kennedy, of going into blast with a coke-furnace. This description is essentially as follows: The furnace is at Ensley, Ala., and as originally constructed, in 1887–88, had the following dimensions: total height, 80 feet; bosh diameter, 20 feet; hearth diameter, 11 feet; bosh located about 37 feet above the hearth level. When remodelled the bosh diameter was reduced to 19 feet and lowered to a point 28 feet above hearth level; the bosh lining was protected by 1¼-inch coils of the Hartmann pattern. The furnace was well dried by nearly a month's hard firing, and the stoves were heated by gas taken from adjoining furnaces; the hearth was filled with a strong cribbing of cord wood and a layer of split pine wood was laid across the furnace at the tuyere level; on this three lengths of cord wood were stood on end; then the fuel blank of Pratt coke, 22,000 lbs. without any limestone, and 78,000 lbs. with 12 per cent. of stone. The burden was composed of equal parts of hard and soft ores and sufficient stone was added to form a slag containing 36 per cent. of silica, allowing for the 2½ per cent. silicon in the iron. The first cinder flushed contained 35.4 per cent. silica. The first seven charges filled contained coke, 6500 lbs.; ore, 4000 lbs.; limestone, 980 lbs. The burden was raised every seven charges until the last charge filled consisted of 6500 lbs. coke, 8700 lbs. ore and 2000 lbs. limestone. A small piece of greasy waste was placed in front of the nose of each tuyere and when all was in readiness 7000 cubic

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feet of blast was turned on through a hot stove. In less than two minutes all the tuyeres lighted, the temperature of the blast being 820 degrees. The heat was ordered to be kept at 800 degrees, and the revolutions increased gradually until at the end of the first 24 hours the furnace was receiving about 16,000 cubic feet. Cinder was tapped 14 hours after lighting and was hot gray and fluid—the first cast was 16 hours after lighting, and contained 17½ tons Nos. 1 and 2 soft iron. The first complete furnace day showed the production of 84 tons, 2400 lbs. to ton, 80 per cent. foundry iron; on the third day 142 tons were made and on the sixth day 155 tons, of which 108 tons were foundry iron. The furnace is now carrying a burden of 6500 lbs. of coke, 2700 lbs. limestone and 11,680 lbs. of ore.

BLAST-FURNACE PRACTICE.—(*Journ. Franklin Inst.*, Aug., 1892.)—John M. Hartmann, in his "Notes on Blast-Furnaces," gives an historical sketch of the manufacture of iron, with a detailed description of the standard commercial grades of pig-iron now manufactured with analyses. An illustrated plate showing appearance of the different grades accompanies the article. The following descriptions of composition and appearance are given, viz.:

No. 1 Pig-Iron.*

Analysis.		Properties.
Iron	92.37	*Gray;* a large, dark, open-grain iron, softest of all the numbers, and used exclusively in foundry. Tensile strength, low; elastic limit, low; fracture, rough; turns soft and tough.
Graphitic C	3.52	
Combined C	.13	
Silicon	2.44	
Phosphorus	1.25	
Sulphur	.02	
Manganese	.28	

* The numbers given are old standard.

No. 2 Pig-Iron.

Analysis.		Properties.
Iron	92.31	*Gray;* a mixed large and small dark grain, harder than No. 1. Used exclusively in foundry. Tensile strength and elastic limit higher than No. 1. Fracture, less rough; turns harder, less tough, and more brittle than No. 1.
Graphitic C	2.99	
Combined C	.37	
Silicon	2.52	
Phosphorus	1.08	
Sulphur	.02	
Manganese	.72	

The tensile strength culminates in No. 3 pig-iron, but falls off more rapidly from No. 3 to No. 5 than from No. 3 to No. 1. Taking the sum of the graphitic and combined carbon in each quality of pig-iron, they are practically the same. The softness of the iron is dependent upon the amount of graphitic carbon in it. It is nearly pure wrought iron

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embedded in the graphitic carbon, and it is the absence of combined carbon which gives it the softness and flexibility that makes it desirable for machinery and other purposes. The grains of iron are crude crystals and when the iron is nearly pure and allowed to cool very slowly regular octahedral crystals of iron are formed.

No. 1 pig-iron may be defined as being composed of grains of wrought iron, connected together but imbedded in graphite.

No. 2 pig-iron has more combined carbon which converts the wrought iron into a soft steel harder to the tool working it.

No. 3 pig-iron has more combined carbon and the iron portion is a crude steel harder to the tool working it.

Nos. 4 and 5 are virtually crude, high combined carbon-steels.

No. 3 Pig-Iron.

Analysis.		Properties.
Iron	94 66	*Gray;* small, close grain; harder than No. 2. Used either in rolling-mill or foundry. Tensile strength and elastic limit higher than No. 2. Turns harder, less tough and more brittle than No. 2.
Graphitic C	2.50	
Combined C	1.52	
Silicon	.72	
Phosphorus	.26	
Sulphur	Trace.	
Manganese	.32	

No. 4 Pig-Iron.

Analysis.	A.	B.	Properties.
Iron	94.48	94.08	*Mottled*, white background, dotted closely with small black spots of graphitic carbon; little or no grain. Used exclusively in the rolling-mill. Tensile strength and elastic limit lower than No. 3. Turns with difficulty; less tough, and more brittle than No. 3.
Graphitic C	2.02	2.02	
Combined C	1.98	1.43	
Silicon	.56	.92	
Phosphorus	.19	.04	
Sulphur	.08	.04	
Manganese	.67	2.02	

[The manganese in "B" pig-iron replaces part of the combined carbon making the iron harder and closing the grain, notwithstanding the lower combined carbon.]

No. 5 Pig-Iron.

Analysis.		Properties.
Iron	94.68	*White;* smooth white fracture; no grain. Used exclusively in rolling-mill. Tensile strength and elastic limit much lower than No. 4. Too hard to turn, and more brittle than No. 4.
Combined C	3.83	
Silicon	.41	
Phosphorus	.04	
Sulphur	.02	
Manganese	.98	

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SLAGS.—In the advance sheets of *Transactions of the American Institute of Mining Engineers*, for June, 1892, is a very interesting and thorough paper on the "Calculation of Slags," by N. M. Langdon. The subject is discussed under the three cases, viz.:

I. A certain percentage of silica is required, it being known in a general way that the amount of other slag-making elements present will offer no hindrance to the formation of a fusible slag with that amount of silica.

II. The slag is required to conform to a general type; that is, to have a certain oxygen ratio of bases to acid (SiO_2).

III. The slag is required to conform to a special type; that is, to have a certain oxygen ratio of protoxide (RO) to sesquioxide (R_2O_3) bases as well as of total bases to acid (SiO_2) or to contain certain percentages of the different bases and acid elements.

The analyses of the fuel, ores and flux, and the type or percentage of the different elements of the required slag being given, the calculation of the proportion of ores and flux may be reduced to the simplest form by following the rules given. Examples are worked out covering the following calculations:

1. To find the percentage of limestone or flux required to produce a slag having a given percentage of silica.
2. To find the percentage of limestone required to produce a slag having a given oxygen ratio of bases to acid.
3. To determine the general type or oxygen-ratio of a slag of given analysis.
4. To resolve a slag given by its formula with the percentage of its elements.
5. To determine the specific formula of a slag, analysis of which is given.
6. To find from the analysis of different ores, flux and fuel, a mixture that will produce a given specific slag.

To aid in the calculations, tables are given on "constants of bases for various percentages of silica required in slags, on "type slags" and amount of silica saturated by 1 of bases to produce a normal silicate, *i. e.*,

$$\left.\begin{matrix} 2\ RO \\ 2\ R_2O \end{matrix}\right\}\ 2\ SiO_2,\ 2R_2O_3\ \Big\}\ 3\ SiO_2.$$

LEAD.—Advance sheets of *Transactions of the American Institute of Mining Engineers* for October, 1892. The Zeehan and Dundas Smelting Works, Tasmania, by George F. Beardsley. Describes location and geology of mines, and the process of smelting, giving illustrations of the furnace. This furnace is 40 inches x 136 inches at tuyeres and 20 feet high; the special feature being the support of the cast-iron water jackets which are held in place by a jack-screw arrangement permitting the easy removal of each jacket without disturbing its neighbor. The analysis of ore treated from the Maestries Mine is

	Per cent.
Pb,	38 to 41
FeO,	21 to 24
MnO,	4 to 6
SiO_2,	7 to 8
S,	2 6
Ag,	25 to 30 oz. per ton.

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Type slag produced is:

	Per cent.
FeO,	40
CaO,	20
SiO_2,	30

Deficiency of ore in silica supplied by adding sand. Furnace capacity, 80 to 90 tons per 24 hours.

SILVER. LIXIVIATION.—Advance sheets of *Transactions of the American Institute of Mining Engineers* for June, 1892.

The Marsac Refinery, Park City, Utah, by C. A. Stetefeldt. This paper covers the present practice of the Marsac refinery, giving the description of the plant and the method of operation. The precipitates produced are:

1. *Base Sulphides*, obtained in precipitating the silver bearing wash water by sodium sulphide, containing when dry 2200 to 5200 ounces of silver, and 1.6 to 3.9 ounces of gold per ton, with 2.6 to 5.2 per cent. of copper and 38 to 45 per cent. of lead.

2. *Carbonates*, obtained in precipitating the hyposulphite solution by Solvay soda, containing when dry 600 to 1,400 ounces of silver and 0.6 to 1.9 ounces of gold per ton, with 23 to 48 per cent. of lead.

3. *So-called "Regular" Sulphides*, obtained by precipitating the hyposulphite solution with sodium sulphide (after precipitating by Solvay soda), containing when dry 11,200 to 12,000 ounces of silver and 11.1 to 12.1 ounces of gold per ton, with 28 to 38 per cent. of copper and from trace to 1 per cent. of lead. About 85 per cent. of the total silver produced by the mill is concentrated in the regular sulphides.

The description of the plant includes matting furnace, pulverizer, muffle furnace, Roessler converter, dissolving tanks, filter tanks, crystallizing vats, wash water tank, Koerting pumps, tanks for precipitating cement copper, cake press, drier for silver cakes and the building. The process is described under Matting, Pulverizing the Matte, Roasting, Dissolving, Filtering, Washing and Pressing the Silver; Crystallizing Blue Stone, Precipitation of Cement Copper, and Labor. Estimates of costs are given and a discussion of the loss of silver in refining.

FUEL. OIL.—(*Journal of the Franklin Institute* for October, 1892.) "The Ærated Fuel Company's System of Burning Oil by Compressed Air, by W. S. Collins. This article gives the general requirements of a perfect oil fire as follows:

1. That it shall be capable of giving the varying degrees of heat required in each line of work, and be subject at all times to the instant control of the workman.
2. That it shall produce complete combustion leaving no smoke or smell.
3. That it shall be entirely free from sulphur or other impurities.
4. That it shall be capable of being made a more or less oxydizing flame.
5. That it shall be as safe if not safer than a coal or wood fire.
6. That it shall be at least as cheap in cost of fuel as coal or wood.

The experiments which have been made to obtain these results may be divided into three general classes:

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1. A retort or system of retorts is employed to convert the oil into gas before it is burned. The objection raised to this plan is in nearly every case the use of more or less complicated apparatus necessitating a special arrangement of the fire box which unfits it for service in the event of the stoppage of the gas generating device.

2. This class uses steam or steam and air to atomize the oil. The objection to every steam jet burner is that it cannot be successfully used in all kinds of work, as it is difficult to get the highest degree of heat when steam is mixed with oil, and the heat from a steam jet burner can not be perfectly regulated nor made subject to instant control.

3. This class relies upon air alone to atomize the oil, accomplished in two ways. One by spraying the oil, which is allowed to run on the tines of a fork in the burner by means of air under six or eight ounces pressure from a fan blower. Chief objections against this system are

a. That it necessitates a gravity system for the flow of the oil.

b. That it requires more power to run a fan than a compressor to spray the same amount.

c. That a fan blast burner consumes nearly one-third more oil for a given amount of work than the compressed air burners.

The other air spraying system is to subject the oil to sufficient pressure to lift it from the storage tank placed below the point of combustion to the top of the burners where it is met by air under the same pressure and driven into the fire through an orifice from one thirty-second to five-eighths of an inch diameter. This system is known as the compressed air system.

The balance of the article is devoted to a detailed description of the plant necessary for this system, giving separate illustrations of blower, exterior and interior view of burners, pump and tank. The system is now used in over two hundred plants in this country, doing about fifty different kinds of work.

COPPER. PRACTICAL NOTES ON THE ELECTROLYTIC REFINING OF COPPER.—*Eng. and Min. Journ.* (Aug. 1892) gives abstract of paper read before the Chicago meeting of the American Institute of Electrical Engineers by F. B. Badt.

From the census report the production of copper in the United States for 1889, was 79,847 tons of 2000 pounds; of this amount it has been estimated that 25,000 tons have been refined by electrolytic processes.

There are four different processes in vogue, viz.: Multiple, Smith's, Hayden's and Stalman's, all using black copper as the anode, the electrolyte being sulphate of copper. The essence of these processes are as follows:

Multiple, anodes of black copper and cathodes of pure copper of each cell are arranged alternately in a row but connected in multiple; generally one more cathode than anode, the electrodes are suspended vertically in lead lined wooden vats, and the vats are either in series-multiple, or multiple series; the best arrangement being single series.

Smith's, no cathodes, anodes of black copper, arranged horizontally, and the current causes the solution of copper from the inner side of each plate and a deposition of it on the upper side of the plate below. A cotton cloth screen is placed between each plate to intercept impurities or foreign matter as gold and silver; the anodes and the vats are all in series.

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Hayden's, differs from Smith's only in the fact that the plates of black copper are arranged vertically instead of horizontally, and have no screens between them.

Stalmann's, anodes of black copper and cathodes of pure copper are arranged in ordinary series, but each pair of anodes and cathodes except the initial and terminal ones, is riveted together to form a solid block without any electrolyte between.

A table is given stating the name and the location of the works using the electrolytic process, the style of generator, number of vats, arrangement of vats and estimated capacity in electrolytic copper per month. Approximate cost of a refinery with capacity of 1,000,000 pounds per month, including $80,000 worth of copper under treatment and a $20,000 steam plant is $223,000.

LEAD. H. O. Hofman in *Eng. and Min. Journ.* for Sept. 3, 1892, gives the calculation of charge for the lead blast-furnace, the typical slag being known and the analyses of ores, flux and fuel. The method in use resembles Murray's,* and elaborated by Newhouse.† In the issue of Sept. 17, 1892, page 270, is a table of analyses of materials used, with the respective co-efficients of bases and acids. This table was inadvertently omitted from the earlier article and clears up some points in the original article that appear obscure.

PYROMETERY.—(*Journal of the Iron and Steel Institute*, vol. i., 1892.)—"On Platinum Pyrometers" by H. L. Callendar, M.A.

In the original Siemens Electric Pyrometer the coil of platinum wire is wound on a clay cylinder and packed in an iron tube five to eight feet long and an inch or two in diameter.

Upon examining one of these pyrometers which had been used at temperatures never above 900° C. or 1600° F., its resistance had increased some 15 per cent. corresponding to an error of 100° F. in the temperature measurements. When the instrument was taken apart it was found that the wire was quite rotten and brittle in some places and sticking to the clay cylinder. The modern improvement in this style of pyrometer has been in the winding of the platinum coil upon sheets of mica, which at 1200° C. has no action whatever on the wire. Other improvements are the substitution of glass or porcelain tubes for the iron tube, and in the uses of platinum leads in high temperature work. These leads are fused (not soldered) on to the fine wire of the coil. In the measurement of the resistance of these pyrometers the differential galvanometer method has been employed, using a resistance box reading to $\frac{1}{20}$ ohm, corresponding to about 3° F., and a table is issued giving the resistance for every 20° F. The disadvantages of this method are that the readings are discontinuous, and it is necessary to refer to the table and do an interpolation sum to find the temperature.

For modern use of this style pyrometer the Wheatstone bridge method is far superior to the differential galvanometer. The advantages claimed are

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* *Engineering and Mining Journal*, Aug. 13, 1887, and Mar. 5, 1892.

† SCHOOL OF MINES QUARTERLY, ix., p. 373.

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1. Superior accuracy.
2. Continuous readings, and
3. The divisions of the wire can be made to correspond directly to degrees of temperature.

Great efficiency is claimed for this instrument and while indicating temperatures as high as 1000° C., a change of $\frac{1}{10}$ of a degree is plainly shown by the galvanometer.

In the appendix to this volume is given a description of the New Optical Pyrometer of Cornu and le Chatelier, by B. H. Thwait. This pyrometer is composed of a photometer, consisting essentially of a telescope associated structurally with a standard of comparison oil light lamp. The flame image of this lamp is projected upon a mirror fixed at an angle of 45° and placed internally across the junction of the tube branch of the lamp with that for sighting the incandescent object to be tested. The intensity of the luminous beam projected from the oil lamp flame and that issuing from the furnace or other heated or incandescent object whose temperature is required to be determined, is equalized and the degree of adjustment required to effect this equalization enables the temperature to be determined.

By means of this instrument M. le Chatelier gives the following important temperatures:

Basic Bessemer Converter (Roberts).

	Degrees Cent.
Period of blow,	1330°
End of blow,	1580°

Six-Ton Converter.

	Degrees Cent.
Bath of slag,	1580°
Metal in ladle,	1640°
Metal in ingot mould,	1580°
Ingot in re-heating furnace,	1200°
Ingot under hammer,	1080°

Open-hearth Furnace (Siemens) Semi-mild Steel.

	Degrees Cent.
Fuel-gas near generator,	720°
" entering into bottom of recuperating chamber,	400°
" issuing from recuperating chamber,	1200°
Air issuing from recuperating chamber,	1000°
Chimney-gases, furnace in perfect condition,	300°
End of melting of pig-charge,	1420°
Completion of conversion,	1500°
Molten steel, in ladle, at beginning of casting,	1580°
" " end of casting,	1490°
" in moulds,	1520°

For very mild steel the temperatures are higher by 50° C. The bath of steel in the central part of the furnace is of a higher temperature than toward the ports.

	Degrees Cent.
Siemens crucible or pot furnace,	1600°
Rotary puddling furnace,	1340 to 1230°
Puddled ball at end of operation,	1330°

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Blast-Furnace (Gray Bessemer Pig).

	Degrees Cent.
Opening in face of tuyere,	1930°
Molten metal, commencement of fusion,	1400°
" end, or prior to tapping,	1570°
Hoffman's red brick kilns,	1100°

REFRACTORY MATERIALS.—(*American Manuf.*, for Nov. 11, 1892).—F. W. Luhrman in his article on "Refractory Bricks for Blast Furnaces" states that the causes of wear of a furnace brick are:

1. Friction from descent of charge.
2. Action of gases as cyanogen and cyanides.
3. Action of chlorides proceeding from the coke.
4. The carbon of the decomposed carbonic oxide which is precipitated over the iron of the bricks causes them to splinter.

Summarizing the discussion of these distinctive causes we have:

1. The abrasion by descent of charge is very little at the present time, owing to the perfection of the modern manufactured brick. So this course of deterioration is reduced to nearly nothing.

2. The cyanogen in blast-furnace gases and its combination with alkaline metals, alkalies and perhaps with volatile metals, is sufficient to cause rapid corrosion of the furnace above the fusion zone. It is not known whether cyanogen at the high temperature carries off the alkalies contained in the bricks and destroys them, or whether it combines first with the alkalies of the charges and attacks the masonry in the form of cyanides. In any case these salts are found in large quantities in the water which cools the walls, and sometimes they pass through the joints of the masonry and fall in drops.

3. In coal mines saline sources are often found; the water, the coal, and especially the endorsing strata, very often contain chloride of sodium. This salt is volatilized in part and comes in contact with refractory bricks heated to a white heat by the combustion of the gases. The silicic acid decomposes it into sodium and chlorine, and the former combines with the silica and alumina of the bricks, producing a fusible slag. The chlorine also attacks the walls.

A brick from a furnace where these experiments were made gave 7.17 per cent. of soda. It is evident that in recuperating coke furnaces where the gaseous products are washed in condensers, the volatilized salts can no longer be injurious. A part of the chloride of sodium always remains in the coke, and in blast-furnaces corrosion is carried on from the volatilized salt. This corrosion of refractory material by salts is taken into account in glazing earthenware or fayence. Salt is thrown into the furnace where the articles are heated and combines with the silica, forming a fusible slag, which, spreading over the surface, produces a glaze.

4. The best refractory clays very often contain pyrites, which is reduced by the action of the gases of the furnace. The carbonic oxide in the presence of iron is decomposed into carbonic anhydride and carbon. This free carbon is precipitated upon the metallic grain and accumulates there, forming a covering and eating into the bricks. No refractory substance can resist the destructive influence caused by the carbon which accumulates more and more. The bricks become eaten away, break off in splinters and are at length completely destroyed. To avoid this cause of deterioration carbon bricks are now used in place of the refractory clay ones.

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BOOK REVIEWS.

BLOWPIPE ANALYSIS. By J. Landauer, translated by James Taylor. Second ed. revised and enlarged. Small 8vo., 173 pp., $1.10. Macmillan & Co., London and New York.

This edition of Landauer's work like the first is accurately and concisely written. It comprises the ordinary details of apparatus, manipulation, behavior of metals and oxides, Bunsen's flame reactions and special examinations of certain compounds. Many convenient tables and a systematic course of examination are given.

In the opinion of the writer the work may be criticized for its failure to bring into prominence from the general mass those striking and unmistakable tests which may be applied to any ordinary compound and to which the other tests are simply confirmatory or often, except on pure oxide or element, quite unobtainable. There is to be noted also some important omissions, for instance, the violet or rose color obtained by action of concentrated sulphuric acid on tellurium compounds, either by dropping the latter into the boiling compound or by obtaining a sublimate on porcelain and moistening with the acid.

The tests from hydriodic acid or its equivalent are briefly described, but not recommended for mixtures. In the work at the School of Mines we find them of great importance. The same may be said of the use of plaster or gypsum tablets which we have found not only to supplement charcoal, but for many tests, especially with As, Sb, Pb, Bi, Hg, to replace it as neater and more satisfactory.

The book is neatly and clearly printed. A. J. M.

MANUAL OF QUALITATIVE BLOWPIPE ANALYSIS AND DETERMINATIVE MINERALOGY. By F. M. Endlich, S.N.D. Large 8vo., xv. and 456 pp. New York: The Scientific Publishing Co., 1892.

This work is the equivalent of the qualitative portion of Plattner's blowpipe analysis, brought to date and supplemented by numerous tabulations of the tests and several general and special schemes for systematic examination. In addition to this, one hundred and forty-seven pages are devoted to mineral tables, classified by lustre, malleability and hardness, with groups in each division according to (usually) some test with the blowpipe. Each group table records prominent tests and characters.

To facilitate the determination of species names, after determination of the composition by the blowpipe, Mr. Endlich devotes twelve pages to a tabulation of minerals by their component elements. The horizontal columns are the basic elements, the vertical are oxides, sulphides, sulpharsenites, etc. When the composition Pb, Cu, Sb, S, for instance, has been determined the horizontal column Lead and the vertical column Sulph-antimonids intersect in a square containing a number of names, of which only one, bournonite, is marked (+Cu).

In new tests may be noted the use of a mixture of $KHSO_4$ and KNO_3 to produce strongly-colored sulphates of certain bases (Co, Ni, Cu, V, Di) and after solution of the fused mass to develop by heating with zinc

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and H_2SO_4 the characteristic reduction color tests of Mo, W, Ti, V, Cb.

The general accuracy and thoroughness of the book is not questioned. For class work in mineralogy the chief objection is that the time allotted to mineralogy even in a professional course such as chemistry or mining engineering is not apt to be sufficient to enable the student to do justice to the regular course outlined in the introduction and to also acquire a due degree of "sight knowledge," or power to recognize without testing, which is even more useful than great skill in determination.

The book would be improved by entering in the table of contents the positions of the XXVII. divisions so constantly referred to and by numbering the tables pp. 284–95 in accordance with their description p. 283. A mineral index should also be added. A. J. M.

A MANUAL OF PRACTICAL MEDICAL AND PHYSIOLOGICAL CHEMISTRY. By Charles E. Pellew, E.M. Illustrated. D. Appleton & Co., New York, 1892.

The work of Mr. Pellew is a new departure in the method of chemical instruction of medical students. The plan followed is similar to that of the legion of works on Practical Elementary Chemistry, so deservedly popular at the present day, but various new and ingenious ideas are introduced in the work. It is very difficult to know just how far to go and how much ground to cover in a subject of such broad dimensions, but so far the author appears to have happily chosen a middle course. The work is neither too trivial nor too abstruse, but seems to suit the purpose thoroughly. As a pioneer in the field, it deserves commendation and shows care and appreciation of the subject in its preparation. A brief review shows that the subject is treated under ten heads, as follows:

1. The Carbohydrates.
2. The Fats and Fixed Oils.
3. The Proteids or Albuminous Bodies.
4. Inorganic Constituents.
5. Water Analysis.
6. Animal Tissues and Secretions.
7. The Digestion.
8. The Urine.
9. Microscopic Examination of the Urine.
10. Appendix, Tables and List of Apparatus.

Under each head we have a brief introduction, containing the definition, occurrence, composition, general properties and the classification of each group. This is followed by discussion of each compound and its occurrence, preparation, composition and properties. Then follows a series of well selected laboratory experiments, including the preparation and testing of the compounds treated in the previous chapters. These tests are generally both chemical and microscopical. An example of the work done is the preparation of starch and cellulose from the potato, conversion of starch into Dextrin, Maltose and Glucose, by dry heat, by boiling with acid, by diastase and by saliva. Examinations of starch under the microscope and the various approved chemical methods for the detection of glucose.

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Under the head of Cane Sugar, we find fermentation, examination for yeast and distillation and tests for alcohol.

The chapter on Oils and Fats is brief but sufficient to give an idea of principles and practice of saponification and the tests on butter, cod-liver oil, etc.

The chapter on the Proteids is full and complete, far more so than in other works on this branch of chemistry. The same applies to the following chapters, especially those on Water Analysis, Milk and Urine.

The work is especially to be commended for the clear and concise statement of tests and experiments as well as the ingenuity shown in the construction of simple and cheap forms of apparatus.

The illustrations are good and sufficient in number to explain the text.

On the whole, the author is to be congratulated in having written a book which puts before the student in a new and interesting manner the chemistry of physiology and in having inaugurated a change in the chemical instruction so long given to medical students. The change cannot be other than beneficial. H. T. V.

THE STEAM ENGINE. By Daniel K. Clark. Blackie and Son, Limited, London, England, and New York.

Mr. D. K. Clark, the author of this exhaustive treatise, needs little introduction to technical readers. His previous publications and his long practice give great value to his selection of matters relating to the steam engine, from the volume of such practice which is accessible in these days. This, his latest work, is characterized by that same thoroughness which is so satisfactory a feature in his other work, and is divided into four main sections. The first two he calls respectively "The Principles and Performance of Steam Boilers and Steam Engines," and the second two he designates by the terms "Construction of Steam Boilers and Steam Engines," so that it will be seen that from the practical standpoint, the discussion is intended to be exhaustive.

The first few chapters on combustion, fuels, etc., are of course fundamental to the latter discussion, and are a review and revision of the corresponding chapters in the *Manual for Mechanical Engineers*, which is still a standard book of reference for all practitioners.

The review of the distribution of the furnace heat with special reference to the experimental investigations which have been made along this line, are particularly interesting, and a review of the Johnson experiments on American coals for the navy brings again into accessible shape material which to many of the present generation has become almost inaccessible. It is but natural that much greater space should be given to the corresponding series of trials with trans-Atlantic coals, but this of course gives particular value to the publication where its primary use may be expected. The chapters covering fifty pages giving a full discussion of the experiments tried in various places for smoke prevention are, so far as known to the writer, unique with respect to fulness and completeness, and will be of special interest to those in the soft coal cities struggling for the abatement of the smoke nuisance.

The collation in nearly one hundred pages of a series of trials of boilers of different types—American and foreign—including the Isherwood, Emery and Loring naval trials, the American Institute Exhibition

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trials of 1871, the Centennial trials of 1876, and an extensive series of trials less known to Americans, with boilers of a wide diversity in design, brings together a mass of information for reference which has only hitherto been accessible to him who could command a large library.

The chapter on relative grate area and heating surface is followed by one upon mechanical stoking apparatus, which is very interesting as bringing together the various methods which have been presented during many years for this purpose, but does not give the reference to the successful American forms of this apparatus, which would seem to be called for, in view of their successful operation.

The chapter on gas firing and powdered fuel furnaces, and the discussion of hand-firing *versus* gas-firing, would have been more complete if there had been included a discussion of the use of oil, which is a subject of increasing consideration from advanced practitioners in this country.

The first half volume concludes with a discussion of chimneys and begins the treatment of the work of steam in a single cylinder.

The second half volume continues the work of steam in a single cylinder and in the compound engine, discusses expansive working, the testing by thermal analysis and the frictional resistance of engines.

This is characteristically full and exhaustive, but the discussions, diagrams and illustrative examples, are very largely taken from standard English practice, which is, of course, as respects the compound engine confessedly in advance of the earlier practice in this country, even if no longer quite as much so.

This volume begins also the discussions of the construction of steam boilers from the standpoint of the strength of the elements, riveted joints, seams, etc., and is followed by an elaborate presentation of the different forms of the boiler, both shell and sectional as it appears in this and other countries.

The first half of the second pair of volumes is taken up with the construction of the steam engine, very copiously illustrated as to details of construction and referring in very creditable fulness to a number of the engine details which America has contributed to successful practice. The Rider, Borter, Corliss, Leavitt and Worthington mechanisms are very satisfactorily exhibited. The special requirements of rail and sugar mill engines, blowing and portable engines receive their proportionate treatment.

The final division is taken up with the locomotive in its simple, compound and fireless forms for street car railway service, giving due reference to American types, although of course, giving naturally a predominence to non-American designs, to an extent which is very instructive to a reader already familiar with the prevalent types on this side the water. To one who is not so familiar, and who seeks to learn in advance as to what he will meet in his world of observation, the discordance between his reading and observation would naturally be something of a surprise.

The final section on marine steam engines, double, triple and quadruple, single and double screw, is very full and satisfactory, as the English type has very largely conditioned the development of the American form. The paddle-wheel engine also, in its inclined form, is one with

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which the trans-Atlantic engineers are much more familiar, and its discussion in the book makes it especially valuable for that reason.

The final section of this part is given over to launch engines and certain special marine gears.

The book closes with an addenda, index and table of contents; the addenda covering certain points naturally attaching themselves to various points in the book.

As a record of the state of the art in boiler and engine construction and performance, at the present time, the book is of great value, and is one of those monumental productions of immense labor, which for that reason is exceedingly noteworthy. To the engineer and expert familiar with American methods, it is of signal usefulness, as bringing to his notice in compact form illustrations of successful practice, more or less out of his usual track. The young student needs to be cautioned in its perusal, lest for this very reason, he forms impressions which his later practice and observation would be compelled to overthrow. As a repertorium in certain special lines, it is invaluable and indispensable

F. R. HUTTON.

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BULLETIN OF ALUMNI AND COLLEGE NEWS.

THE DEATH OF PROF. TROWBRIDGE.

A special meeting of the Alumni Association of the School of Mines was called, under the constitution, for the evening of November 11, 1892, at No. 12 West 31st Street.

As stated in the call, this meeting was for the purpose of taking action by the association upon the death of Prof. Trowbridge, and of considering what steps, if any, should be taken in reference to the creation of some permanent memorial, by which his memory could be kept constantly before the minds of students in the School of Mines.

The chairman announced the object of the meeting, whereupon the following memorial minute was read by Mr. A. W. Hale, the senior graduate present:

The members of the Alumni Association of the School of Mines, of Columbia College, convened in special session, have learned with sincere sorrow of the death on August 12, 1892, of Prof. William P. Trowbridge, who had occupied the chair of engineering from 1877 until his death, and was an honorary member of this association. They desire to place upon their records a memorial minute, in which they may endeavor to express something of the affection and esteem in which they have held their former instructor, and of their sense of loss in his removal by death.

As an engineer he was a man of notable breadth and variety of experience, and of wide reputation. As the first to propose the cantilever system for long spans; as a servant of his State on important commissions; as a consulting expert in many wide issues, he has commanded universal respect and consideration.

As an instructor he always commanded the affectionate enthusiasm of his classes from his intimate and thorough acquaintance with the topics of his specialties, and his firm grasp of the fundamental principles underlying successful practice. His aim was to make first, engineers, and afterwards to train the specialist. But it is for the man and the friend that his old students most desire to record their warmth of devoted feeling. Ever unselfish and devoid of self-interest; always genial and affectionate, yet never undignified, "his boys" were always sure of interested friendship for them from him whose character they had learned to admire and to love.

The School of Mines, the engineering department and the wide circle of former students, all are the poorer for the loss they have sustained, and the alumni beg to unite in expressing their sympathy for those to whom his removal brings the keenest pang.

Resolved, That this memorial minute be spread in full upon the records of the association.

Resolved, That the secretary of the association be requested to transmit a copy of this action to the family of Prof. Trowbridge with their sincere sympathy.

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These resolutions were passed with a rising vote, as the unanimous action of the entire body present.

The secretary read a number of letters from alumni unable to be present, expressing their full sympathy with the idea of a permanent memorial, and making suggestions as to the shape which such memorial should take. Among the proposals were: a monument at the grave in New Haven, a tablet or bust in a suitable place in the new college building, an oil painting in the library, or an invested fund, the income of which to be used either to award yearly a prize in the engineering department, to furnish a scholarship for deserving students in the school, or for the purchase of books on engineering, to be kept in a designated alcove in the library, or to support a fellow, to be known as the "Trowbridge Fellow," who should devote himself to advanced researches in engineering.

The discussion of the subject was very general, and the objections to the plan of a prize for under-graduates and of a scholarship for an under-graduate were referred to. As the result of the discussion the following resolution was proposed by Mr. A. L. Beebe, and passed in its amended form:

Resolved, That a committee be appointed by the chair to ascertain the amount which can be secured from the alumni of the school and from others who have been connected with it, with authority to collect such subscriptions when they come due, said money to be devoted to the establishment of a fellowship in the school, for a graduate in engineering, amounting to the income of $10,000, and to be known as the 'Trowbridge Fellowship.'

The detail as to the disposition of this money shall be determined at a subsequent meeting of this association, at which the said committee shall report."

At the close of the discussion on this resolution and its final passage, the association adjourned.

The committee under the above resolution is appointed by the chairman, Prof. Elwyn Waller, is as follows:

Executive Committee on Trowbridge Memorial: H. S. Munroe, '69; Chas. M. Rolker, '75; W. B. Kunhardt, '80; W. F. Morgan, '84; D. L. Dresser, '89.

General Committee: John A. Church, '67; Wm. Pistor, '68; Elwyn Waller, '70; P. de P. Ricketts,' 71; F. R. Hutton, '76; Wm. E. Hildreth, '77; B. B. Lawrence, '78; H. Hollerith, '79; A. L. Colby, '81; W. F. Downs, '82; Robert Peele, '83; C. F. Lacombe, '85; John H. Janeway, '86; George Rowland, '87; G. J. Volckening, Jr., '88; E. M. Blake, '90; George Leary, '91; Robt. D. White, '92.

The following is appended as a type of many similar resolutions showing the hearty love of the graduates for the late professor:

"At a special meeting of the Executive Committee of the class of '87, School of Mines, Columbia College, held Thursday, September 29, 1892, the following resolutions were adopted:

WHEREAS, In the death of Prof. William Petit Trowbridge, our friend and former preceptor, we, the members of the class of '87, School of Mines, Columbia College, have sustained a deep personal loss.

Resolved, That we hereby express our appreciation of his marked ability and sterling character, and extend to his family our heartfelt sympathy in their bereavement.

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Resolved, That these resolutions be engrossed upon the records of the class, and inserted in the journals of the university.

Resolved, That a copy of these resolutions be sent to the family of the deceased.

Committee: A. L. Burns, George Rowland, W. C. A. Ferguson, S. Edson Gage, Harry P. Nichols.

ENGINEERING DEPARTMENT.

The death on August 12, 1892, of Prof. W. P. Trowbridge, professor of engineering in the School of Mines, made necessary some provision for the conduct of the work of the department at the opening of the school year.

The president of the college requested Prof. Hutton, the senior in the department, to assume charge as its head *ad interim* and to provide by distribution for a temporary assignment of duty, so that there might be no interruption of the departmental work. The emergency was met by assigning to Adjunct Prof. Greenleaf the instruction in Stoney and in water supply and river and harbor engineering, which Prof. Trowbridge had had heretofore, while he himself assumed the responsibility for the courses in thermodynamics, dynamics of engineering, motors, etc. Mr. A. E. Foyé, tutor in civil engineering, has relieved Prof. Hutton of his popular course in railroad engineering, and Mr. Hurlbut has taken his course in machinery and millwork.

Meanwhile, a committee of the faculty has been appointed to consider the question whether it may not be judicious to advise a different organization in the engineering department from that which has prevailed since 1877, and it is expected that this committee will report in detail before very long. It is anticipated that their report will advise the creation of a separate chair of civil engineering, and will arrange for the transference to the department of mechanics in the school of much of the fundamental and preliminary work which has hitherto been carried on by the engineering department, thus relieving its officers for fuller devotion to advanced work.

GEOLOGICAL DEPARTMENT.

Several new features have been developed in the work of the department. The trustees voted in the spring an appropriation for summer work in geology. This has been applied by adding a week of geological field work to the Summer School of Practical Mining, and it is the intention to make this a regular feature of the summer trip. Last season Mr. Hollick joined the class on Keweenaw Point. A week was spent in studying the geology and running sections across the country in the vicinity of the Atlantic Mine. The report on these with accompanying drawings will furnish a required portion of the usual memoir. A second expedition for the collection of materials for original investigations during the year, was made to Mount Adam and Mount Eve, near Warwick, Orange County, N. Y. These two intrusive knobs of granite have penetrated limestones and given some interesting exhibitions of contact metamorphism. The party consisted of Prof. Kemp, Mr. Hollick and Messrs. Ries and Fenner, of the class of '92. Two weeks were spent in the field in June. Something similar will be again carried

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out next summer. Mr. Hollick has also been aided by the appropriation in preserving his investigations on the Cretaceous fossil plants of Long Island, and some interesting and important developments have been made. During the summer Prof. Kemp has done the field work preparatory to a description of the westerly granite district of Rhode Island. In August and September in company with Mr. W. D. Matthew, '93, he was in the field for the New York State Museum, in the eastern Adirondacks. The systematic work thus begun on this region, it is hoped to continue regularly in the future.

The courses of the departments of Mineralogy and Geology are now so arranged that crystal measurement and optical mineralogy are taught in the former and preparation thus given for petrographical work in the latter. In this last subject Prof. Kemp gives two lectures weekly and as much additional laboratory work as the student elects. The work is required of students in the course in geology and is suited for advanced degrees. Mr. Hollick offers similar opportunities in palæobotany and in like amount. By arrangement with Professor Osborn, of the department of biology, Dr. Bashford Dean, of that department, will give students in the course in geology two exercises weekly in vertebrate palæontology. Dr. Dean also delivers the lectures in the regular second year course in zoology, which is now under the biological department. Some valuable additions of fossil fish from Ohio have been made to the collections, and they are now in Dr. Dean's hands for description. A collection of about three hundred and twenty-five specimens of igneous rocks, each accompanied by a thin section, have been bought in Germany the past year and added to the regular equipment.

The movement was started last winter of inviting several graduates of the School of Mines, who had been engaged in geological work, to take one of the regular hours in general or economic geology, and address the class and others who felt interested, on some subject on which the lecturer had been specially engaged. The invitation was intended as a recognition of services to the science on the part of Alma Mater. A most interesting lecture was delivered by Mr. Bailey Willis, '78, on his experimental researches in mountain-making forces as illustrated in the Appalachians. We also hoped to hear from Mr. W. P. Jenney, '69, and Mr. W. H. Weed, '83, but they were prevented coming. Mr. Weed promises to visit us this year, and Mr. Jenney we have not given up.

A book on the Ore Deposits of the United States by Prof. Kemp, is announced by the Scientific Publishing Co. (*Engineering and Mining Journal*) as being in press.

Additional floor space and case room have been provided in the museum for the systematic arrangement of palæobotanical material, a large part of which is at present packed away in store-rooms. Much of this represents Dr. Newberry's unfinished work on the recent extinct flora of North America, and the flora of the Amboy clays, which Mr. Hollick is now engaged in completing for publication.

Department of Biology.

The following courses of lectures will be given by the department of biology, in room 11, Library Building, on successive Thursday evenings, at eight o'clock, beginning November 10, 1892. They are de-

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signed for those who desire to keep abreast of the later advances in biology without entering any of the technical courses:

"History of the Theory of Evolution." By Henry F. Osborn, Sc.D., Da Costa Professor of Biology.—November 10, Introduction. November 17, Among the Greeks. December 1, The Predecessors of Lamarck. December 8, Lamarck. December 15, Darwin. December 22, The Post-Darwinian Period.

"The Cellular Basis of Heredity and Development." By Edmund B. Wilson, Ph.D., Adjunct Professor of Biology.—January 12, Introduction; Cellular Basis of the Living Body. January 19, The Germ-cells; Sex and Fertilization. January 26, Cell Genesis and Division. February 2, Egg and Spermatozoön; the Preparation for Development. February 9, Physiology of the Individual Cell. February 16, Intercellular Dynamics; Theories of Heredity.

"Origin and Evolution of the Fishes." By Bashford Dean, Ph.D., Instructor in Biology.—February 23, The General Structure of Fishes. March 2, Sharks and Rays—fossil and recent. March 9, The Teleosts. March 16, The Ganoids. March 23, Chimæra and the Lung-fishes; the Newberry collection of Giant Placoderms. March 30, Embryology of Fishes.

"Amphioxus and Other Ancestors of the Vertebrates." By Arthur Willey, B.Sc., Tutor in Biology.—April 6, Introduction; History, Mode of Live and Distribution. April 13, General Structure. April 20, Nervous, Vascular and Execretory Systems. April 27, Reproduction and Development. May 14, Larval Growth and Metamorphosis; Relationships of Amphioxus to other Types.

Department of Botany.

In co-operation with the American Museum of Natural History, the following lectures are to be given at the Museum, Central Park (Seventy-seventh Street and Eighth Avenue), on Saturday evenings, at eight o'clock. The first course will be on "The Jesup Collection of North American Woods," and will be delivered by N. L. Britton, Ph.D., Professor of Botany, Columbia College.

The lectures will be illustrated by lantern projections of the more important timber trees, their foliage, flowers, fruit, and the structure of wood:

November 19, The Deciduous-leaved Trees. November 26, The Deciduous-leaved Trees, continued. December 3, The Deciduous-leaved Trees, concluded; The Palms. December 10, The Coniferous Trees.

Department of Electrical Engineering.

There are this year 66 students taking a course in Electrical Engineering, against 26 students last year. In the first-year class there are 31 students taking Electrical Engineering.

A course of lectures on the applications of electricity with special reference to engineering will be given by Prof. Crocker to the Third

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Year Mining Engineering students during the second term of this year.

DEPARTMENT OF METALLURGY.

The department has received from Chas. Bullman, of the class of 1883, a batea and two cachos, such as are used in the Republic of Colombia in working gold and other sands.

From E. M. Hawkes, of the Class of 1885, a set of metallurgical blue prints, which is to be one of a number to be loaned to the students when a sufficient number shall have been collected.

The department has secured a Mahler's calorimeter, a Le Chatelier photometric pyrometer and a horizontal grinder and section cutter.

Mr. R. C. Boyd, of the class of 1891, has been appointed Fellow in Metallurgy, with Geology and Mineralogy for his minor subjects.

The addition of the Chatelier photometric pyrometer to the collection of pyrometers already in the possession of the department, viz., the Siemens calorimetric; the Siemens electric; Mesuré and Nonels optical; Chatelier's thermo-electric, and Seger's pyramids, is of valuable importance, as their relative efficiencies can be determined by the latest accepted standard work in this direction is now in progress.

The collection of metallurgical specimens is being developed along lines of modern and special practice. The endeavor is, to cover the entire metallurgical field; but, special attention is directed to malleable iron-castings; spigeleisens; ferro-manganese; open-hearth, crucible, and cement steels; copper and lead.

The department would be grateful to any who would care to aid us in this work by sending specimen suites illustrating the various steps in the different process, or any specimens showing peculiar working, or worthy of examination. The co-operation of graduates is earnestly asked.

DEPARTMENT OF MINERALOGY.

The collection has been greatly improved by the alteration of the large wall-cases, formerly filled with furnace models; these cases now contain handsome large specimens—on one side, quartz, opal, pyroxene, amphibole, etc.; on the other, minerals of antimony, silver, copper, lead, gold, etc.

The department has received six very large specimens from the Copper Queen Mining Company; and a very exceptionally handsome specimen of the hair-like Millerite associated with dolomite and calcite, from Missouri.

The courses for advanced work in optical mineralogy and mathematical crystallography, arranged in conjunction with the advanced course in petrography given by Professor Kemp, have been further developed. The instrumental equipment is now very fine, there having been added, this year, a third section cutter for cutting slices at definite angles to the axis; a Westphal balance for use with specific gravity solutions; another Beck microscope; a small photographic outfit, and a magnificent Duboscq lantern with arc-light.

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A large number of interesting minerals are being investigated; the results of these investigations will be published from time to time. The department asks the graduates in the field to forward to the Mineralogical Department any specimens which appear to them either unusual or exceptionally characteristic, or, in any way deserving of examination. The officers will, as rapidly as possible, report their results, without any other charge than the privilege to retain the specimen in the School's collection, and to ask for more specimens.

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J. S. Newberry

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THE

SCHOOL OF MINES QUARTERLY.

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In Memoriam.

PROFESSOR JOHN STRONG NEWBERRY.

BY J. F. KEMP.

THE faculties of Columbia College have suffered heavy losses in the twelve months just ended, and some of the names most honored on the rolls, appear in their accustomed places no longer. Professors Peck, Dwight, Trowbridge and Newberry have followed one another in quick succession from the scenes of instruction and work, in which they so long and so honorably formed conspicuous figures. It remains for the college community to hold in grateful remembrance the efforts, which were freely expended during many years in its behalf.

Although born in Windsor, Conn., December 22, 1822, and of New England parentage, Dr. Newberry passed the greater portion of his early life in the Western Reserve of Ohio. When he was but two years of age, his parents removed to Cuyahoga Falls, south of Cleveland, so that from this time until he entered college, his boyhood was passed in a new but progressive settlement. The surroundings were such, however, as to strongly influence the future scientist. The elder Newberry became engaged in opening up the coal resources of eastern Ohio, and in obtaining an outlet

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for them to Lake Erie. His son was thus reared in the midst of mining, and of that kind of mining which especially developed fossil plants. In his later years, Dr. Newberry took pleasure in recounting the delight which he felt, while yet a boy, in uncovering these delicately preserved fronds from their enclosing shale. The geological museum still possesses some of the finest slabs, which his early efforts brought to light. In the same section remains of fossil fish began to appear and foreshadowed the fame, which has later come to it, as one of the regions most prolific of these early organisms.

After preparation for college the future professor entered the Western Reserve University at Hudson, Ohio, and was graduated in 1846. He next studied medicine in the Cleveland Medical School and received his degree of M.D., in 1848. The attractions of European study led him shortly afterward, to Paris, where he spent two years in further preparation in medicine. Interest in fossils prompted him also to seek instruction in palæontology, but as he was accustomed many years later to speak of the unsatisfactory character of his opportunities, they probably amounted to little. While abroad he wrote his first scientific contribution, a description of the fossil fish locality at Monte Bolca, Italy, so that even at this early date he manifested the interest in fossil fish and plants, which gave later direction to his chief scientific efforts.

On returning to America, he began in 1851, the practice of medicine in Cleveland, and soon gained a wide clientele. It is a curious fact that in the same year in which Dr. Newberry sought European advantages, Leo Lesquereux, his great contemporary palæobotanist migrated from Switzerland to America.

While Dr. Newberry's medical practice increased and many influences conspired to develop him into a settled and successful physician, his tastes for natural history kept making his profession more and more irksome. Friends at Washington were not slow to take advantage of this, and finally induced him to abandon Cleveland and active practice. He became in May, 1855, assistant surgeon and geologist to the exploring party that was sent out by the War Department, under Lieut. R. S. Williamson, to traverse the country between San Francisco and the Columbia River. Two years later his papers on the botany, zoology and geology of the region appeared in Vol. VI. of the "Reports of Explorations and Surveys to ascertain the most practicable and

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economical route for a railroad from the Mississippi River to the Pacific Ocean, made in 1853–56," Washington, 1857.

Dr. Newberry next became geologist to the Ives expedition as it is generally known from its commander, Lieut. Joseph C. Ives. This party was sent to explore the Colorado River, in 1857–58. After sailing up the river from the Gulf of California in a little steamer to the mouth of the Grand Cañon, the party spent nearly a year in its study and exploration. Dr. Newberry not only gained an acquaintance with the superb geological sections and phenomena of erosion there afforded, but also with the Pueblo tribes of Indians, in whom he ever afterwards took the deepest interest. The geological portion of the final report forms what is now its most valuable and interesting part. The full title is, "Report upon the Colorado River of the West, explored in 1857–58," Washington, 1861.

In 1859 Dr. Newberry was again in the field as naturalist of an expedition under Capt. J. N. Macomb, which traversed the San Juan region, in southwestern Colorado, and the adjacent parts of Utah, Arizona and New Mexico. Many observations on the coal seams and general geology of this country are recorded, to the accuracy and importance of which later and fuller reports have given ample confirmation. The results of this expedition were not made public until 1876, owing in part at least to the demoralization of the war. They then appeared under the title, "Report of the Exploring Expedition from Santa Fe, to the junction of the Grand and Green Rivers," Washington, 1876. In addition to its geological details, the report contains many interesting records about those prehistoric tribes, the cliff dwellers, whose ruins are abundant in the region.

Shortly after the trip was completed the civil war broke out. Dr. Newberry was summoned to the newly organized Sanitary Commission, in which on June 14, 1861, he took his place, although at the time attached to the War Department. But the work of the Commission was imperative and in September, Dr. Newberry resigned from the War Department and became Secretary of the western branch of the Commission, with headquarters at Cleveland. All the operations in the Mississippi Valley and its tributaries were under his direction. Distributing depots were quickly established at many points. At times Dr. Newberry followed the army and was himself present at the battle of Chatta-

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nooga, overseeing the work of his organization. At the close of the war, he made his final report. It is a volume of 543 pages, and exhibits the great labors performed, and the enormous sums, which were expended under his administration. Dr. Newberry had by this time returned to Washington and had become attached to the Smithsonian Institution. He also held a professorship in the Columbian University of Washington, to which he had been called in 1857.

In 1864 the School of Mines, Columbia College, New York, was founded, and in 1866, the chair of Geology and Palæontology was created and a call was extended to Dr. Newberry. He accepted and remained in the uninterrupted discharge of his duties, until a stroke of paralysis, December 3, 1890, made work impossible. It was never resumed.

This long interval of twenty-four years is marked by incessant activity, for, in addition to instruction in the college, a vast amount of investigation and writing was carried on. Opportunities for scientific work and distinction outside of New York appeared, and made possible the greatest efforts of his life. When the Legislature of Ohio established a State geological survey in 1869. Dr. Newberry, who had all along kept his household and home in Cleveland, was called by Governor Hayes, to the directorship. Active organization was soon effected and a comprehensive scheme of work was blocked out. Three reports of progress were issued, the last extremely brief. The final reports comprised four volumes on the geology of the State, two on its palæontology, one geological atlas and a report on the zoology and botany. They all appeared between 1869 and 1882. One or two were printed in German as well as English. A large part of the field work was done by the director himself, and the descriptions of a number of counties are from his pen. Naturally the summation is also his. In palæontology notable discoveries were made of fossil fish and fossil plants. The reports on these two groups, by Dr. Newberry probably attracted more attention from scientific men than any other results of the survey's work. Observations on the geological history of the Great Lakes, and their relationships to the Glacial Period were recorded, which have proved fruitful of later results. Not a few men began their geological work or took part in the survey, who have since become leaders. G. K. Gilbert, R. D. Irving, Henry Newton, N. H. Winchell and Edw. Orton, the

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able and courteous director of the present Ohio survey, may be mentioned. Probably an error of judgment was committed in postponing the economic work until the last, for, before these reports, which always have greatest value and interest to the people at large, were reached, the legislature cut short the appropriations, on the ground, as one rural member said, that too much money was devoted to clams and salamanders.

Dr. Newberry also did a large amount of palæontological work for the Illinois survey, especially on vertebrate fossils. A still more extended undertaking was the description of the later extinct floras in the west, materials for which had been gathered by the Hayden survey. A volume of plates was issued in 1878, but although begun nearly fifteen years ago, the manuscript is not entirely complete, and if published, will form a posthumous work under the editorship of the professor's old student and friend, Arthur Hollick. In association with the New Jersey survey, Dr. Newberry also undertook the description of the flora of the Amboy clays. This manuscript, with some editoral completion by Mr. Hollick, will also appear as a posthumous work. The description of the fossil fishes and plants of the eastern Triassic strata, was pushed to a conclusion and appeared in 1888, as Monograph XIV of the U. S. Geological Survey. A more elaborate work on the Palæozoic Fishes of North America, came out in the following year as Monograph XVI of the same survey. Both volumes are extensively illustrated by plates. In addition to his palæontological papers, Dr. Newberry wrote also many shorter contributions for the scientific journals on subjects connected with economic geology. He was frequently called upon to prepare articles for encyclopædias. Papers on geological subjects were furnished by him to Appleton's *American Cyclopædia*, Johnson's and the *Encyclopædia Brittanica*. This sketch would be incomplete without mention of the high regard that was felt for his opinion on the value of mines, both for metals and for coal. His advice was often sought, and repeated trips to the west and to Mexico widened his range of observation. In this connection, it may also be stated, that he was one of the judges at the Centennial and wrote the report on building stone.

When the National Academy of Science was founded, Dr. Newberry was named by Congress as one of the incorporators, and became a familiar figure at its meetings. In 1867 his Alma

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Mater honored herself and him by bestowing the degree of LL.D. In the same year he was president of the American Association for the Advancement of Science, and delivered the annual address at Burlington, Vt. Likewise in 1867, soon after his coming to New York, he was chosen president of the New York Academy of Sciences, Professor C. A. Joy, the previous incumbent, gracefully and generously retiring, to give the Doctor an appropriate introduction to the scientific circles of the metropolis. For twenty-four years, Dr. Newberry remained president of this body, and during the last year of his life and at the time of his death was its honorary president. Dr. Newberry also became president of the Torrey Botanical Club, and occupied the position from 1880 up to 1890—a period of ten years.

Largely in immediate recognition of his palæontological work, the Geological Society of London, conferred on Dr. Newberry in 1888, the Murchison gold medal, which is awarded by the society for distinguished scientific services in geology. In presenting the medal, President Judd, and in receiving it for Dr. Newberry, Sir Archibald Geikie referred in a most appreciative way to his work. When the long pending Geological Society of America finally took form at Cleveland in 1888, Dr. Newberry was present and shared in its organization. At the second election of officers in New York, December 26, 1889, he was chosen first vice-president. The crowning honor of his life came, however, in 1891.

In the late seventies the subject of an International Congress of Geologists was broached in the American Association, and Dr. Newberry was appointed one of the committee to carry the matter through. The movement led to the organization of the Congress, which has now held four meetings, at intervals of three years, and in several countries. The last was in Washington in August, 1891, and chose for its presiding officer the one in whose memory these lines are penned. The honor was a fit tribute to a long and fruitful life, but it came after its recipient was too weakened to take the chair. From his far distant summering place on Lake Superior, he was forced to send his messages of greeting to the Congress.

It was in the winter of 1889–90, that exhausting labors began to tell heavily on a constitution, which had seemed such proof against fatigue, that it knew not how to yield. A heavy cold and attendant weakness gave warning that certain limits must be re-

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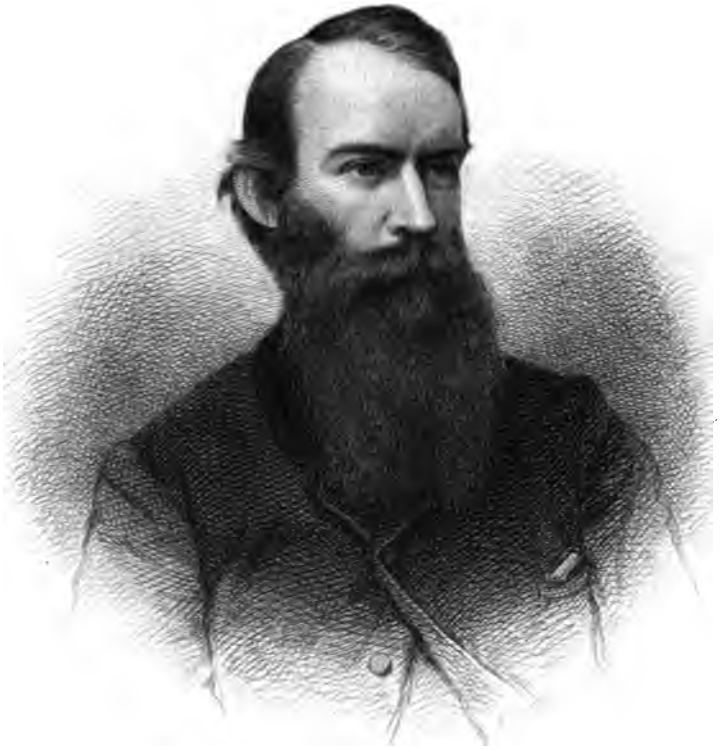

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garded, but the professor after a brief absence, again appeared before his classes. When the long summer vacation of 1890 came, he wrought day after day with an amanuensis on his report upon the Amboy flora. The strain was too severe and culminated in the following December, with a paralytic stroke, from the effects of which the honored teacher and investigator never recovered. Two years later he passed away on December 7, 1892, lacking just a fortnight of being seventy years of age.

Dr. Newberry's skilful touch has been felt in almost all lines of geological work, and in almost all departments of natural history. Not only did he have a love of investigation and study, but he was also a most indefatigable collector, and made the geological museum in the School of Mines a monument to his memory. Its wealth of fossil fish and fossil plants makes it unique and famous among geological museums. All that we know of many genera of the former is based upon material now in the cases.

Dr. Newberry had many other interesting sides to his nature, for the scientific man never becomes the master, who does not combine with all his closeness in observing and his accuracy in statement, a strong poetic or spiritual endowment, call it what we may, which leads him to grasp almost by intuition the harmonies of nature, and to appreciate the beautiful things of art. Dr. Newberry had a strong passion for music, and in his earlier years was wont to solace the lonely hours of western expeditions with his violin. Old students in the School of Mines remember how he used to sing to himself in a rich, full voice, while working in the geological collections. Often in the still hours of the night, the music of his little cabinet organ swelled out from his apartments. He was likewise skilful in the use of his pencil, and many illustrations of fossils and of scenery in his reports are from his own hand. He wrote in charming and attractive style, and in descriptions of the grand phenomena of the west, often manifested a highly artistic use of words.

In his scientific work, he sometimes displayed almost the insight of a seer, and from his ability to grasp as by intuition the bearings of many widely separated facts, he has shown a quite prophetic instinct. His determinations of strata in the west, although based on the hasty itineraries of exploring parties, have been very generally corroborated by later and more deliberate work. The same is true of his early views on the origin of

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petroleum, and on the buried channels, that have been since discovered around nearly all the waterfalls of the central part of the country. He was, withal, extremely conservative on many doubtful points and before his classes was very cautious of statement. With his students his relations were marked by great kindliness, and by them he was universally beloved. Not a few have gone out from his instruction to successful work in the science to which he was devoted. He also numbered among his friends, scientific men in all parts of the world, and several New Year's greetings have come unsought from friends across the water, who had not yet learned that he was beyond their reach.

Dr. Newberry was married in Cleveland in 1848, to Miss Sarah B. Gaylord, who with six of their seven children, five sons and one daughter, survives him. Two of his sons are graduates of the School of Mines.

A bibliography of his works is appended, which was largely prepared by himself, just before his illness. It is believed to be quite complete.

LIST OF PUBLICATIONS OF PROFESSOR J. S. NEWBERRY.

1851.

"Description of the Quarries Yielding Fossil Fishes, Monte Bolca, Italy."—Family Visitor, 1851.

"On the Currents of the Gulf Stream and of the Pacific off Central America."—Family Visitor, 1851.

"On the Geographical Distribution of Certain Species of Land and Fresh Water Shells."—Proc. Amer. Asso. (1851), p. 105.

"On the Origin of the Quartz Pebbles of the Carboniferous Conglomerate."—Family Visitor, 1851.

1852.

"On the Specific Identity of Typhus and Typhoid Fevers."—Minutes Ohio State Medical Society, 1852.

1853.

"On the Fossil Fishes of the Cliff Limestone."—Annals of Science (1853), p. 12.

"On the Structure and Affinities of Certain Fossil Plants of the Carboniferous Age."—Proc. Amer. Asso. (1853), p. 157; Annals of Science, Vol. I., p. 268.

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"On the Carboniferous Flora of Ohio."—Proc. Amer. Asso. (1853), p. 163; Annals of Science, Vol. I., p. 280.

"Catalogue of the Fossil Plants of Ohio."—Annals of Science (1853), Vol. I., pp. 95 and 106.

"New Fossil Plants from Ohio."—Annals of Science (1853), pp. 116, 128 and 153.

1856.

"New Genera and Species of Fossil Fishes from the Carboniferous Strata of Ohio."—Proc. Phil. Acad. Sci. (1856), p. 96.

1857.

"Report on the Economic Geology of the Route of the Ashtabula and New Lisbon Railroad."—Cleveland, Ohio (1857), 8vo., pp. 49.

"On the Mode of Formation of Cannel Coal."—Amer. Jour. Sci., Vol. XXIII (1857), p. 212.

"Geology of California and Oregon."—United States Pacific Railroad Report, Vol. VI. (1857), pp. 1–73, pl. V.

"The Botany of Northern California and Oregon."—United States Pacific Railroad Report, Vol. VI. (1857); Botanical Report, pp. 1–94, pls. I–XVI.

"Zoology of Northern California and Oregon."—United States Pacific Railroad Report, Vol. VI. (1857), pp. 37–110, pls. I–V.

"Fossil Fishes of the Devonian Rocks of Ohio."—Bulletin National Institute, January, 1857.

"Reports of the Geology, Botany and Zoology of California and Oregon."—Reprint from P. R. R. Report, Vol. VI., 4to., pp. 250, pl. XXXIX.

1859.

"Catalogue of Plants of Ohio."—Ohio Agric. Report (1859), and Reprint, pp. 41.

"The Rock Oils of Ohio."—Ohio Agric. Report (1859), and Reprint, pp. 16.

"Explorations in New Mexico."—Amer. Jour. Science, Vol. XXVIII. (1859), p. 298.

1860.

"Cretaceous and Tertiary Plants."—Hayden's Report on Exploration of Missouri and Yellowstone Rivers, Washington (1859-60), p. 146.

"The Ancient Vegetation of North America."—Amer. Jour. Sci., Vol. XXIX. (1860), p. 208.

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"The State-House Well of Columbus, Ohio."—Report of Supt. of State House, 1860, and Reprint.

"The Aurora of 1859."—Amer. Jour. Sci., Vol. XXX. (1860), pp. 347–356.

"The American Cretaceous Flora."—Amer. Jour. Science, Vol. XXX. (1860), p. 273.

1861.

"Geology of the Colorado Exploring Expedition."—Washington (1861), 4to., pp. 153, pl. 6, 2 maps.

1862.

"The Surface Geology of the Basin of the Great Lakes."—Proc. Boston Nat. Hist. Soc., Vol. IX. (1862), and Reprint, pp. 7.

"Notes on American Fossil Fishes."—Amer. Jour. Science, Vol. XXXIV. (1862), pp. 73.

1863.

"Description of Fossil Plants Collected by the N. W. Boundary Commission."—Proc. Bost. Nat. Hist. Soc., Vol. VII. (1863), and Reprint, pp. 19.

1866.

"The Oil Region of the Upper Cumberland in Kentucky and Tennessee."—Cincinnati, 1866, pp. 10.

"Prospectus of Neff Petroleum Company, Knox County, Ohio."—(1866), pp. 16–23, pp. 40–43. Gambier, Ohio.

"Report on the Fossil Fishes Collected on the Illinois Geological Survey, by J. S. Newberry and A. H. Worthen."—Rept. Geol. Survey Ills., Vol. II. (1866), pp. 1–134, pl. XIII.

1867.

"Modern Scientific Investigation, its Methods and Tendencies."—Presidential Address, Proc. Amer. Asso. (1867), p. 1, Reprint.

1868.

"Report on the Fossil Plants Collected in China by Mr. Raphael Pumpelly."—Smithsonian Contributions (1868), p. 119, pl. 1.

"Sketch of the Geology of Ohio."—Walling's Atlas of Ohio (1868), with geological map.

1869.

"Geological Survey of Ohio."—Report of Progress for 1869, Part I., pp. 1–52, map and chart.

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1870.

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Dr. Newberry was also one of the editors of Johnson's Encyclopædia, having charge of Geology and Palæontology. He wrote many articles on these subjects for its pages.

Biographical sketches of Dr. Newberry have been published in all the current biographical dictionaries and cyclopædias. Portraits of him appear accompanying such sketches in "Men of Progress," 1870–71, p. 317, and "Contemporary Biography of New York," Vol. V., 1887, p. 255. The Popular Science Monthly, Vol. IX., p. 491 (1876), contains a sketch with portrait, and in Fairchild's History of the New York Academy of Sciences, there is an excellent artotype. Since his death memorials have already appeared with portraits in the Engineering and Mining Journal, Dec. 17, 1892, p. 581, and the Scientific American, Dec. 31, 1892, p. 423, while others have been read before our principal scientific societies, or are in preparation for them. Of the two portraits accompanying this memorial the younger was taken in 1864 and the older in 1887.

[Note.] The above bibliography was prepared in its essentials by Dr. Newberry himself. It has been edited by J. F. Kemp and Arthur Hollick, by whom a number of additions not in the original draft have been made. The original contained no references between 1874 and 1878. Should omissions be noted by any friend, the editors would be grateful if their attention should be called to them.

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STANDARDS OF LINEAR MEASURE.

By EDWIN P. CLARK. E.M.

THE art of measuring consists of ascertaining how many times the object measured contains a certain fixed and determinate quantity known as the *unit.* The unit is physically represented by some object universally recognized as exactly defining it, which is called a *standard.* In practical use, measures, whose relation to the standard are known, are applied directly to the distance or substance sought to be measured.

"The want, at least of measures of length, is founded in the physical organization of individual man, and precedes the institution of society. Were there but one man upon earth, a solitary savage, ranging the forests and supporting his existence by a continual conflict with the wants of his nature, and the rigor of the elements, the necessities for which he would be called to provide would be *food, raiment, shelter.* To provide for the wants of food and raiment, the first occupation of his life would be the chase of those animals, the flesh of which serves him for food, and the skins of which are adaptable to his person for raiment. In adapting the raiment to his body he would find at once, in his own person, the want and the supply of a standard measure of length, and of the proportions and subdivisions of that standard.

"To the construction of a dwelling place, superficial measure becomes essential, and the dimensions of the building still bear a natural proportion to those of its destined inhabitants. Vessels of capacity are soon found indispensable for the supply of water; and the range of excursion around the dwelling could scarcely fail to suggest the use of a measure of itinerary distance. Measures of *length,* therefore, are the wants of individual man, independent of and preceding the existence of society. Measures of surface, of distance, and of capacity, arise immediately from domestic society. Itinerary measure, as it needs nothing more than the prolongation or repetition of linear measure, would seem at the first view to be the same. Yet this is evidently not the progress of nature. As the want of it originates in a different stage of human existence, it will not naturally occur to man to use the same measure, or the same scale of proportions and numbers, to clothe his body and to mark the distance of his walks. On the contrary, for

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the measurement of all objects which he can lift and handle, the fathom, the arm, the cubit, the hand's-breadth, the span, and the fingers, are the instruments proposed to him by nature; while the pace and the foot are those which she gives him for the measurement of itinerary distance."*

Aside from theoretical considerations, it is the fact that the use of measures is very ancient, and precedes the earliest ages of which we have any accurate historical knowledge. Josephus says that Cain invented weights and measures when he departed into the land of Nod and built a city. The Egyptians attributed their invention to Thoth, the god of letters, and the Greeks to Hermes —Mercury.

Frequent attempts have been made, from time to time, by scientific men and others, to show that the ancient Egyptian system of weights and measures was founded upon the ascertained length of a degree of the meridian; that there was a scientifically determined relation between the units of measure of length, weight, and capacity; and that the various measurements of the great pyramid of Gizeh were intended to indicate these units, and also, by their multiplication, as shown in its different dimensions, to prophetically announce some of the most important events of the world's history. These hypotheses rest upon no valid foundation whatever, it having been shown that the agreement between these ancient measures and their supposed unit is only fanciful, and disappears upon close investigation and accurate measurement; it being also well known that the necessary scientific knowledge and skill for performing such a task as the measurement of a portion of a meridian of the earth did not exist in the remote ages when the measures were invented, or even when the pyramid was built.† Dr. Heinrich Brugsch, in an article on "Die Geschichte vom Pfund," in a recent number of *Die Gartenlaube*, states that the basis of the measures of the ancients, finally settled upon after long search and many observations, was the diameter of the sun's disc as it looks to the human eye, viewed from the earth at the time of the equinox, being equivalent to two cubits. This is purely an imaginary idea, and lacks all semblance of accuracy, for it is perfectly apparent that the diameter of the sun can be made equal

* John Quincy Adams, Report upon Weights and Measures, Phil., 1821, pp. 6–7.

† For an exhaustive examination of this subject, and a refutation of the hypotheses above mentioned, see Pres. F. A. P. Barnard, "Metrology of the Great Pyramid," SCHOOL OF MINES QUARTERLY, V. Nos. 2, 3, and 4, pp. 97, 193, 289, *et seq.*

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to one inch, one foot, or one yard, according to the distance from the eye at which the measure is held.

There can be little doubt but that all measures of length were ultimately derived from parts of the human body, although, it is to be observed, that they are generally longer than the average length of the respective parts of the body from which they are taken and named, which evidently indicates that they were derived from the members of some man, a chieftain or leader, above the average stature. "The actual employment of dimensions of the human body for the purpose of determining the unit of length is not, as one might be inclined to think, a matter of a very remote past, in proof of which," the following quotation is made from a German work on surveying by Jacob Koebel, published about 1550: "To find the length of a rood in the right and lawful way, and according to scientific usage, you shall do as follows: Stand at the door of a church on a Sunday, and bid sixteen men to stop, tall ones and small ones, as they happen to pass out when the service is finished; then make them put their left feet one behind the other, and the length thus obtained shall be a right and lawful rood to measure and survey the land with, and the sixteenth part of it shall be a right and lawful foot.'"*

The distance from the point of the elbow to the end of the middle finger, being a sharply defined and readily applicable unit of length, seems to have been the most ancient and universal standard. This is the distance known as the *cubit*. We also have the digit, thumb, palm, hand-breadth, span, foot, pace and fathom, and also the yard, which was derived originally from the Saxon *gyrdan*, girth. As these measures came into use independently, at different times and places, they varied greatly among themselves, and were not necessarily commensurate with each other, although there was a generally recognized proportion between them, shown by the following table:

	Parts.
Digit (breadth of the middle part of the first joint of the forefinger),	1
Palm or hand-breadth,	4
Span,	12
Foot,	16
Cubit,	24
Step or single pace,	40
Double pace,	80
Fathom (distance between tips of fingers when arms extended),	96

* E. A. Gieseler, C.E., "Standard Measures," *Journal of the Franklin Institute*, 126, 3 ser., 96, pp. 115–16.

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Units of measure were transmitted from one people to another by means of commerce, and thereby a certain amount of uniformity arose as the standards of some one people came to be accepted over a large area and local units gradually abandoned. This is the case with weights to a greater extent than with measures. The Phœnician weights spread all through the Mediterranean countries, the Persian through Asia Minor, and the Assyrian through Egypt. Nevertheless, as there was no scientific basis of ancient metrology and no ideas of accuracy as defined by modern scientific methods, even these ultimate crystallized standards of ancient times varied considerably, not only at different times and places, but even at the same time and place. Evidence is not lacking that the units were suddenly and arbitrarily altered at times (sometimes for the purpose of modifying taxation), by the orders of sovereign rulers or by the priestly custodians of the standards. Special systems grew up for the use of special trades or communities, or for dealing in special commodities. Eventually the greatest confusion arose, which was remedied by a complete reorganization. A sort of natural history of the development of measures might be outlined according to the following steps:

I. Primitive personal measures.

II. Primitive standard units and original systems.

III. Combined and expanded series of measures. Royal and priestly systems. Special trade systems.

IV. Confusion, giving rise to uncertainty, injustice and dishonest practices.

V. Reorganization.*

"Most ancient measures have been derived from one of two great systems, that of the cubit of 20.63 inches (British standard), or the digit of .729 inch; and both these systems are found in the earliest remains."†

This cubit of 20.63 inches was the standard used in building the great pyramid where its value is 20.620 inches. It is the unit of several Egyptian monuments, and has come down to modern times actually displayed by several cubit rods constructed approximately 1000 years B.C., which, taken together, average 20.65. It is found also in Babylonia, Assyria and Asia Minor. Ten ancient

* L. D'A. Jackson, *Modern Metrology*. London, 1882. Pp. 7, 8, 9.

† W. M. Flinders Petrie, *Encyclo. Brit.*, xxiv., p. 483. The data for the paragraphs immediately following are taken from this source.

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buildings in all give a mean of 20.63 inches. It was specifically divided into fifths, the foot of three-fifths being as important as the cubit. The Greek derivative from this 20.63 inch cubit was the foot of 12.45 inches ($\frac{3}{5}$ of 20.75), which originated in Babylonia. This is the most usual Greek unit; thirteen buildings give an average of 12.45 inches. It can probably be traced to Roman Britain, and seems to appear in the English mediæval building foot of 12.47 inches. As derived from this 20.63 inch cubit we also find the 13.8 inch foot used as the standard of Pergamos, and a cubit of 17.30 inches, which appears in certain Persian buildings and in Asia Minor.

The other system mentioned as founded upon the digit of .729 inch was also of wide extension in use during ancient times. It is sometimes stated that it was derived from the other system; but this is an error, as the two systems are in fact incommensurate. This confusion arose from the division of the 20.63 inch cubit into 28 digits, each of which varies slightly from .729 inch, their incommensurability becoming apparent, however, when greatly multiplied. On some cubit rods it has been found that the first 24 digits were made less than $\frac{1}{28}$ of the cubit in order to agree with the true digit standard, the remaining four being lengthened to fill up the 20.63 inches. This digit is found as a standard in Egypt, Asia Minor, Syria, Persia and Assyria, particularly at Nimrud. We find, as derived from it, a cubit of 18.23 inches ($25 \times .729$), which has no relation to the 20.63 inch cubit. This was probably the cubit in use among the Hebrews in the time of the kings. It also seems to be the Olympic cubit. The Greeks also obtained a foot by taking $\frac{2}{3}$ of this cubit. This foot is not found in many buildings, but was the unit for land measure. The Italian or Roman foot of 11.62 inches ($16 \times .726$) is also evidently derived from this same system, although possibly indirectly from Greece, some authorities stating this to be the length of the Attic foot.

Besides the standards traced from these two units there were several others known to the ancients which cannot be connected with either; these were the 25.1 inches cubit of the Talmudic temple measures, and royal Assyrian and Persian use; the 21.6 inches cubit in use among the Jews after the captivity, among the Assyrians and in Asia Minor, half of which made the Assyrian foot of 10.8 inches, also known as the South Italian or Oscan foot; this cubit seems to be indicated in prehistoric remains in Britain and

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early Christian buildings in Ireland. Among independent units are also found the 22.2 inch cubit of Carthage; the 20.0 inch and the 19.2 inch cubits found in some ancient buildings; and the 13.3 inch foot found in Asia Minor, whence it passed to northern Greece and seems to reappear as the Belgic foot of the Tungri, which passed over to England, where it was the most common building foot up to the 15th century, averaging 13.22 inches.

The foot, equal to one-sixth of the fathom and one-fifth of the double pace, is the unit in practical use among the English-speaking peoples at the present time. It seems to be derived from Greece, where tradition states that it was regulated by the foot of Hercules. From Greece its use spread over western Europe, but, from the tendency of measures to vary in copying for transmission from one people to another, and more particularly from the fact that the unit was also originated independently in some places, the greatest variety has been found among standards generically known as foot measures. The Pythic foot had a value of 9 and ¾ of our inches; that of Geneva, 19 inches. "In Italy there existed in the year 1832, 215 foot measures of different length; and in Germany, at the beginning of this century, there were certainly not any less, probably many more." Some of these, with their lengths expressed approximately in British inches, are as follows:

	Inches.
Thore,	10.46
Cologne,	10.74
Saxony,	11.14
Hamburg,	11.28
Bremen,	11.39
Bavaria,	11.49
Halle,	11.72
Leipzig,	12.01
Prussia,	12.35
Vienna,	12.43*

Official standards have been made and preserved by most nations; among the ancients they were considered sacred, and were usually kept in temples in priestly custody. These ancient standards must have been arbitrary lengths of wood or metal, which deteriorated by use and thus lost their true value. Modern standards of length are of two kinds known as *end measures* or

* Gieseler, *Jour. Fr. Inst.*, 126, pp. 116, 117.

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line measures. In the former the length of the unit is defined by the distance at a certain temperature between their ends; in the latter it is defined by the distance at a certain temperature between two lines drawn on their surface at right angles to the direction of their length.

In modern times it has been attempted to unite the units of measure of length, capacity and weight into systems with relations scientifically determined and accurately defined, generally making the unit of length the foundation of the whole structure. In formulating such a system two questions present themselves at the outset. "What is intrinsically the best and most available unit of linear measure to adopt as a basis; and secondly, what system of numerical multiplication, and aliquot subdivision of such unit is most advantageous?"* The principal systems that have been used for multiplication and subdivision are:

I. The *binary*, by halves and doubles, which has been found the most advantageous for practical commercial purposes.

II. The *duodecimal*, which also admits very readily of both binary and ternary subdivision.

III. The *decimal*, which is most convenient for calculation, but is somewhat awkward when applied to the daily purposes of trade.

IV. *Mixed* systems, such as the *sexagesimal*, combining the principles of two or more of the foregoing.

In considering the first question it is obvious that standards derived from the human body are not susceptible of reference to a fixed invariable unit; neither are those derived from cereal grains or other natural objects of which the unit is supposed to represent an average. "We are driven, then, in our choice of a *universal* standard, to the selection either of some individual object (if such there be), natural or artificial, imperishable in its nature, unsusceptible of variation by lapse of time or decay, and indestructible by accident—or else, to some ideal or resultant length or magnitude (if such there be), susceptible by its definition of being as it were translated into a material expression, and marked out as the result of some process which we are sure will, in all ages and places, reproduce the same identical result. And besides these qualities of invariability, indestructibility and identical reproducibility, it ought to possess some obvious claim to *general* acceptation as of com-

* Sir John Herschel, "Lecture on the Pendulum, the Yard, and the Metre," as published in Davies' *Metric System*, pp. 298, 299.

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mon interest to all mankind, or at least to all the civilized portion of it; an interest from which national partialities and rivalries should be altogether excluded."* For this purpose several different objects have been suggested. The most prominent are the seconds pendulum, and the fractional part of a meridian of the earth, concerning both of which we shall have more to say hereafter. There have also been proposed the length of a wave of monochromatic light, the velocity of light or the space travelled over by light in some definite time, a fractional part of the equator, and the polar diameter of the earth, which has been found to be very nearly 500,500,000 (mean 500,492,732.8) British inches. The great practical difficulties, and in fact, apparent impossibility of deriving absolutely invariable results from observations of nature, has almost led to the abandonment of this idea of "natural standards," and the establishment of arbitrary standards, reliance being placed upon keeping them intact, and having them duplicated and preserved in several different depositories. Recent experiments, however, tend to show that the relation of a standard to the length of a wave of monochromatic light can be determined to within one part in ten millions with ease and certainty. The brilliant green mercury line seems to be the best adapted for this purpose.† Prof. Michelson has been experimenting with his method at the International Bureau at Breteuil during the last summer with great success, and the probabilities are that a "natural" standard will be established in the manner suggested by him.

The Dutch philosopher Huyghens first demonstrated that the times of vibrations of pendulums depend entirely on their lengths. "He discovered that if a *simple* pendulum (*i.e.*, a weight or *bob* consisting of a single point, and hung by a rod or string of no weight) can be made to describe, not a circle, but a cycloid of which the string would be the radius of curvature at the lowest point, all its vibrations, however large, will be performed in the same time. For a little distance near the bottom, the circle very nearly coincides with the cycloid; and hence for small arcs, a pendulum vibrating in a circle is nearly isochronous." The arc of vibration should not exceed 1° 30′. "The relation between

* Herschel, *ibid.*, pp. 303, 304.

† Albert A. Michelson and Edward W. Morley, "On the Feasibility of Establishing a Light-Wave as the Ultimate Standard of Length, *Am. Jour. Science*, 138, p. 181 *et seq.*, Sept., 1889.

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the time of vibration and the length of a pendulum is expressed thus:

$$t = \pi \sqrt{\frac{l}{g}},$$

where t is the time in seconds of one vibration, l the length of the pendulum, and g the force of gravity at the place where it is intended to vibrate."* From the fact that the earth is not a sphere but an oblate spheroid the force of gravity is variable at diferent latitudes, hence g is a different quantity for each place of observation. By transposition of this formula the theoretical length of a seconds pendulum can be obtained for any particular locality. A good empirical formula for determining the length of a seconds pendulum, in vacuum, at sea level and 62° F. in British inches is

$$l = 39.01307 + (.20644 \times \sin^2 \text{Lat.}).$$

This is deduced from 44 of the most uniform of some 52 observations of the length of the seconds pendulum in different latitudes.†

About 1670 Huyghens conceived the idea of establishing a standard of linear measure from the seconds pendulum, which he proposed to divide into three parts called "horary feet," each of which would be about 13 inches long; this proposition was also endorsed by Picard in 1671, and an analogous one was made by Thomas Jefferson in 1790. Neither the exact length of the seconds pendulum nor any aliquot part of it has ever been established as a standard, but several standards have been compared with it and their relations to it determined, and in some cases declared by statute.

As the construction of a *simple* pendulum is a physical impossibility, it is necessary, for purposes of observation, to use a body of finite dimensions, called a compound or material pendulum, which can be considered as a rigid combination of a number of simple pendulums vibrating around a common axis. In order to determine the time of a vibration of a simple pendulum from that of a compound one, we must first find the centre of oscillation, *i.e.*, a point which, if it vibrated alone around the point of suspension, would have the same duration of vibration as the entire

* Sir Edmund Beckett, *Encycl. Brit.*, vi., p. 14.

† S. C. Walker in *Jour. Frank. Inst.*, 17, New Series 13, p. 101 *et seq.*; gives elaborate formulæ for reduction and correction of observations.

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body, or, in other words, the point at which the whole mass of the pendulum can be considered as concentrated, thus forming a simple pendulum. "The distance of the centre of oscillation from the point about which the rotation takes place, or the length of the simple pendulum having the same duration of oscillation as the compound pendulum, is equal to the moment of inertia of the compound pendulum divided by its statical moment, or the moment of its mass." Then, having observed experimentally the number of vibrations of the compound pendulum in a given time, the length of the simple pendulum beating seconds is easily deducible, as "the number of oscillations is inversely proportional to the square root of the length of the pendulum."*

The observations must be corrected for elevation above sea-level, temperature, barometric pressure, specific gravity of the pendulum used, "vibrating specific gravity," amplitude of arc of vibration and the retarding influence of air adhering to the swinging body; as the coefficients for these corrections are not absolutely determined, sources of error arise, and as more recent investigations tend to show that the force of gravity at any place is dependent upon the density of the earth's crust immediately underneath, and, furthermore, that not only the polar circumference of the earth, but also the equator, is elliptical, thus rendering the theoretical determination of the value of g uncertain, the solution of the exact relation between the seconds pendulum and a standard measure becomes a very difficult problem, and too unreliable for dependence to be placed upon it for reconstruction of an absolutely invariable standard whenever that should become necessary. Besides the plain compound pendulum, various others have been used, such as Kater's reversible pendulum, Whitehurst's differential pendulum, Leslie's pendulum rod, etc.

In 1718 the astronomer Cassini, in his book *De la Grandeur de la Terre*, first proposed another unit, the six-thousandth part of a minute of a degree of a great circle of the earth. This would be nearly equal to one foot, British standard. Nothing followed from this suggestion.

The first measurement of part of a meridian of the earth of which any record is known was made by Eratosthenes some two centuries B.C. The Arabian astronomers gave some attention

* Julius Weisbach, *Theoretical Mechanics*, trans. by Coxe, pp. 648–666.

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to the subject, but the first attempt to carry on such a work by accurate methods was made by the Dutch geodosist, Willebrod Snell, in 1617. From that time until 1735, this and the correlative question of the figure of the earth engaged the attention of philosophers. Sir Isaac Newton, in his *Principia*, demonstrated that the earth was not a sphere but an oblate spheroid. The astronomers Cassini, from the results of their measurements of a portion of a meridian in France, inferred that it was a prolate spheroid. This became a very important question, and the French Academy of Sciences "determined to apply a decisive test by the measurement of arcs at a great distance from each other." Accordingly, two expeditions were sent out; the first, in 1735, proceeded to Peru, where, after ten years of labor, they measured an arc of 3° 7′ intersected by the equator; the other, in 1736, proceeded to Lapland, where an arc of 57′ was measured. These observations proved that the earth was an oblate spheroid.* The standard measure used by these expeditions was the toise. That brought back by the Peru expedition was made the standard of France, at the temperature of 61° F., and was known as the "toise de Peru." It took the place of the "Chatelet toise," which was a standard iron bar let into the steps of the "Chatelet" in Paris, in 1668, and which had been the standard since that time. The "toise de Peru" is equivalent to 6.39453348 British feet.†

In the year 1790 Tallyrand proposed to the members of the Constituent Assembly of France the establishment of a new system of metrology on a single and universal unit. A commission was to be appointed which should consult with a similar English commission and take into consideration the whole subject. Accordingly, the English government was invited to co-operate in this work, but from the distrust engendered by the progress of the revolution in France, no response was made to this invitation. A decree was passed by the Assembly and sanctioned by Louis XVI. on the 22d of August, 1790, under which a commission of five members of the Academy of Sciences was appointed, who, after a careful consideration of the three elementary bases proposed for a

* Col. A. R. Clarke, R.E., F.R.S., *Encyclo. Brit.*, vii., pp. 597, 598.

† For an historical account of the toise and other standards, see the annual address of Dr. William Harkness, Pres. of the Philosoph. Soc of Wash., on "The Progress of Science as Exemplified in the Art of Weighing and Measuring," delivered Dec. 10, 1887.—*Nature*, 40, pp. 376 *et seq.*

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standard,—the seconds pendulum, a quadrant of the equator, and a quadrant of a meridian,—adopted the last because it was more accessible than the second, and could be ascertained with the utmost precision. They rejected the pendulum because it involved the additional element of time. They determined that the one ten-millionth part of a quadrant of the meridian of Paris should be the unit; this was afterwards named the *metre*. An arc of this meridian from Dunkirk on the northern coast of France to Barcelona, Spain, was measured by Mechain and Delambre. The work was commenced in 1792, and, after some interruptions due to the troubles of the French Revolution, completed in 1798. It is interesting to note in passing that the two base lines, each of about 7 miles in length and over 400 miles apart, checked up within 10 or 11 inches. This furnishes a criterion of the care and accuracy displayed in the work. On the completion of the work the length of the metre was determined, and a platinum standard constructed called the "Metre des Archives," which was declared to be the fundamental standard of the French system of weights and measures. Several iron metre bars were made for distribution among the members of the committee having charge of the work, which had been enlarged by the addition of representatives from some of the other nations of Europe. One of these bars came into the possession of the United States Coast Survey through Mr. Hassler. The length of the metre in relation to the British standard has been variously determined, as shown in the following table, in

	Inches.	Inches.
By the French Academy, ...	39.3827	.....
1817-32, by Mr. Hassler (Amer.), . . .	39 380917	39.36994
1818, by Captain Kater (Brit.), . . .	39 37079	39.36990
1835, by Sir Francis Baily (Brit), . . .	39.369678	39.36973
1866, by Col. A. R. Clarke, R.E. (Brit.), . .	39.370432	39 36970
1882, by Prof. W. A. Rogers (Amer.), . .	39.37027	.....
1885, by C. B. Comstock (Amer.), . . .	39.36985	39 36984
Indiscriminate mean, ...		39.36980

which the second column presents the results obtained by reducing some of the determinations of the first column to terms of the "Committee metre bar" of the United States Coast Survey, mentioned above, by making the necessary corrections for difference of temperature of comparison (the metre having been declared to be standard at 0° C. (= 32° F.), whereas the British standard is

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estimated at a temperature of 62° F.), difference in expansibility of the various metals of which the standards compared were constructed, etc.*

By experiments conducted by the Academy, at the time of the determination of the metre, it was determined that the seconds pendulum in vacuum, at 32° F., at sea-level in the latitude of Paris, equals .99385 metres.

In computing the length of the meridian of Paris, the mean ellipticity of the earth as determined by the previous measurements made in France and Peru, was taken at $\frac{1}{334}$th. More accurate and numerous measurements on various parts of the earth's surface have demonstrated that, not only the meridional section of the earth is elliptical, but that the *equator* is also elliptical, its longer axis passing through long. 8° 15′ † W. from Greenwich, and its shorter through long. 81° 45′ E. † Consequently the sections through different meridians give different curves, the mean meridional ellipticity of the earth being about $\frac{1}{295}$, and that of the Paris meridian about $\frac{1}{288}$. It consequently follows that the metre is *not* the natural standard that it was intended to be, being too short by about 1 part in 6404, of about $\frac{1}{163}$ of an inch.‡

"In 1866, the copies of the legal French standards in use in different countries differed among themselves, and their relation to their prototypes was not known with a degree of precision in keeping with the requirements of science; and the standards of the archives themselves, made in the latter part of the last century, were not constructed with the degree of perfection attainable in modern times.

"These considerations and the spread of the metric system, induced the government of France to invite the governments of the world to send delegates to Paris for the purpose of forming an International Commission, having for its object the construction of a new metre as an international standard of length. In response to the invitation, Professor Joseph Henry and Mr. J. E. Hilgard were appointed by the President scientific delegates, without diplomatic functions, to represent the United States. A first meeting was held at Paris in August, 1870, but, owing to the existing po-

* O. H. Tittmann, *Bulletin* No. 9, U. S. Coast Survey, "On the Relation of the Yard to the Metre," June 15, 1889.

† Col. A. R. Clarke, R.E., F.R.S., *Encyclo. Brit.*, x., p. 172.

‡ Sir John Herschel, "Pendulum, Yard, and Metre," Davies, p. 326.

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litical complications in Europe, but little was done until the second meeting, in 1872, when a general plan was outlined, and definite propositions as to the mode of procedure to attain the objects in view were adopted. The most important of these propositions were to make the international metre a line measure whose length at 0° C. should be equal to that of the *Metre des Archives*, . . . and to use for the material of the standards an alloy of platinum-iridium containing 10 per cent. of iridium with a tolerance of 2 per cent. in excess or deficiency.

"The cross-section of the metre bars was also decided upon. It is that proposed by M. Tresca, and is that which was ultimately given to the prototypes." It is a combination of an X and an H, which gives lightness and strength, and reduces to a minimum the error arising from flexure.

"On May 20, 1875, a metric convention was signed at Paris, by the representatives of seventeen governments, among them that of the United States, for the purpose of establishing and maintaining, at the common expense, a scientific and permanent International Bureau of Weights and Measures near Paris. By this treaty, the operations of the international bureau are put under the exclusive direction and supervision of an international committee, which latter is under the control of a general conference composed of delegates from all the contracting governments. According to Article VI. of the Convention, the International Bureau of Weights and Measures is charged with:

"1. All comparisons and verifications of the new prototypes of metre and kilogramme.

"2. The custody of the international prototypes.

"3. The periodical comparison of the national standards with the international prototypes and with their test copies, as well as the comparison of standard thermometers.

"4. The comparison of the prototypes with the fundamental standards of non-metrical weights and measures used in different countries for scientific purposes.

"5. The standardizing of, and comparison of, geodetic measuring-bars.

"6. The comparison of standards and scales of precision, the verification of which may be requested by governments or scientific societies, or even by constructors or men of science.

"On the basis of this convention the international bureau was

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organized, and established in the Pavillon de Breteuil, in Sevres, near Paris."*

Experiments were made with the alloys, and ingots finally cast, which were properly cut up, and from which 31 metre-bars were constructed; these were marked and compared "with each other and with an auxiliary bar whose length in terms of the Metre des Archives had been carefully determined." The co-efficients of expansion were also determined. "One bar, the length of which at 0° C. was found equal to that of the Metre des Archives, was selected for the international prototype," and the remainder, called national prototypes, were distributed among the various governments by lot in September, 1889; those allotted to the United States are metres Nos. 21 and 27. These were packed with great care, and transported to this country, one in October and November, 1889, and the other in July, 1890, and placed in the custody of the U. S. Coast and Geodetic Survey at Washington.†

The foundation of the present British and American system of measures is found in the *yard*, a word of Saxon origin, and derived from *geard, gyrd, gyrdan*, meaning girth, the circumference of the human body. This was brought into England by the Saxons who found already existing the measures of the inhabitants founded upon the Belgic foot of the Tungri, equal to 13.22 inches. This latter gave rise to a yard afterwards known as "the yard and full hand" which was suppressed by statute in 1439—18 Hen. VI., ch. 16. These old British measures were as follows:‡

Foot = 13 22 British inches.
3 feet = 1 yard = 39.66 British inches.
2 yards = 1 fathom = 79.32 British inches.
10 fathoms = 1 chain = 793.2 inches = 66 ± feet.
10 chains = 1 furlong = 660 feet.
10 furlongs = 1 mile = 6600 feet.

It will be observed that we have a survival of the old British system in the Gunter's surveyor's chain, and that the furlong is identical in the old and present systems. Tradition states that the yard lost its character of girth, very soon after the Norman

* O. H. Tittmann, "The National Prototypes of the Standard Metre and Kilogramme," Appendix No. 18, Report of 1890, U. S. Coast and Geodetic Survey, Washington, 1891. See also, article by W. A. Rogers, in *Proceedings* Amer. Acad. of Arts and Sciences, xv. (vii., N. S.), p. 273; and a letter in the *Nation*, 49, p. 329.

† Tittmann, *ibid.*

‡ Petrie, *Encycl. Brit.* xxiv., p. 484.

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conquest, and was adjusted as a standard by the arm of King Henry I.

The Saxon standards were kept at Winchester, prior to 950 A.D., where copies for general use were compared and stamped. King Edgar decreed that "the measure of Winchester shall be the standard." The Normans made no change in the standards, but removed them to Westminster, and placed them in the custody of the king's chamberlains of the Exchequer, who thus became the official custodians of all standards of weight and measure, which came to be known in later times as "the standards of the Exchequer." The yard and ell (from the Roman ulna) were originally identical and continued so down to the time of Richard II. An old statute of 1224 (9 Hen. III.) called "Compositio ulnarum et perticarum" lays down the rule:

3 barley corns = 1 inch.
12 inches = 1 foot.
3 feet = 1 ell (ulna).
5½ ulne = 1 perch.
40 perches in length and 4 in breadth = 1 acre.*

The barley corns were to be from the middle of the ear, round and dry, and to be laid end to end. By a statute of 15 Henry VI. "the *Aulneger* or measurer of ells, is directed to procure for his own use, a cord of 12 yards and 12 inches long, adding a quarter of an inch to each quarter of a yard." This statute marks the era when the woollen manufacture began to be important, this provision being intended to make certain the hitherto vague custom of allowing a thumb-breadth to a yard for shrinkage. In 4 Rich. II. it was ordained that cloths shall be wetted before they are measured. In 10 Anne it is prescribed that "each yard is to have an inch added instead of that which is commonly called a thumb's-breadth." In 13 Rich. II. uniformity in weights and measures was ordained throughout the kingdom, except in "Lancaster, which hath always been used to greater measures than the rest of the realm." †

The oldest existing British standards of length are a yard bar of Henry VII. dated 1490 and one of Elizabeth of 1588. These differ by little more than $\frac{1}{100}$th of an inch from the present Imperial British yard, which is substantially the same as the old

* H. W. Chisholm, *On the Science of Weighing and Measuring and Standards of Measure and Weight.* London, 1877, p. 50.

† *No. Amer. Rev.*, 45, pp. 274–5.

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Saxon yard. Other old standards are a yard measure of 1660 at the Guildhall, London; a yard measure of 1671 belonging to the Clockmaker's Company, and a yard known as "Rowley's Tower Standard" of 1720. In 1742 the Royal Society had a scale very carefully constructed commonly known as Graham's. During the last century the greatest skill in the construction of delicate instruments of precision seems to have been attained by an optician named John Bird. He constructed a number of standards, among others, one for Parliament under the direction of a select committee of the House of Commons appointed in 1758 to inquire into the state of English weights and measures. This committee pursued their inquiries with great system and ability and rendered a very valuable report from which we make the following extracts:

"Your committee . . . . examined Mr. Harris (Assay Master of the Mint), who said, that a lineal or longitudinal measure should be the standard of all measures of capacity; and as the law seemed already to have made the yard the standard, he thought, that to prevent variations, it should be a clean straight brass rod, of about 38 or 39 inches long, and about an inch broad and thick; near each end of this rod, a fine point should be made, and a fine line drawn through it at right angles to the sides of the rod; the distance between the said two points to be the true standard length of a yard; and as the edges of points made in brass were liable to decay, he would recommend two gold studs or pins, to be fixed in the brass rod, on which the points were to be made which ascertain the length of the yard. This rod should be fitted in a proper box, and placed in safe custody, to be used occasionally; but that for ordinary sizing of yards, there should be another rod made, in the same manner as the former, only it should have two upright fixed cheeks; by these cheeks, anything placed between them might be more readily and exactly measured than by the standards now at the Exchequer. . . . .

"Your committee thought it was necessary to pursue Mr. Harris's thought, and therefore had two rods made by Mr. Bird, according to Mr. Harris's proposal; and having those rods, together with that of the Royal Society [of 1742] laid in the same place, at the receipt of the Exchequer, all night, with the standards of length kept there, to prevent the variations which the difference of air might make upon them, they the next morning compared them all, and, by the means of beam compasses brought by Mr.

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Bird, found them to agree as near as it was possible. The rods which they had thus prepared, were sealed up by your committee, and are herewith laid before the House to be disposed of as shall be thought most proper.

"That which your commitee thinks should be the proper standard, if the Legislature shall think fit to make it so, and carefully preserved, is marked thus, 'Standard yard, 1758;' and the other with the cheeks is what your committee would propose to be kept at the receipt of the exchequer for common use, and is divided into three equal parts, each of which is consequently a foot; one of those third parts into twelve, making inches, and one inch into ten equal parts, for the easier adjusting of any comparative measure."*

A similar committee appointed in 1759 made similar recommendations, but no action was taken by Parliament at that time establishing these bars as the legal standard. Bird made another standard known as the "Standard yard of 1760." Its length was taken from the yard constructed in 1758. Each was a solid brass bar 1.05 inches square in section and 39.73 inches long; near each end of the upper surface gold pins or studs, 0.1 inch in diameter, were inserted, on which points or dots were marked, the distance between them determining the yard.

The first accurate comparison and measurement of standards of linear measure according to the criterion of modern scientific methods were made in England in 1797 by Sir George Shuckburgh Evelyn. For this purpose he made use of a comparateur, constructed by Troughton, of London, consisting of two metal rules or scales of superior manufacture; one of these, the standard scale proper, was a bar 67¾ inches long, 1.4 inches wide, and .42 inches thick, on which was marked a scale 60 inches long, divided to tenths of an inch; the other bar was somewhat longer and thicker, was also divided to tenths of an inch, and carried two little metal frames, capable of being moved laterally, and which could be clamped in any desired position; on each of these little frames was mounted a microscope so placed as to be directly over the free movable scale when placed alongside of the supporting one. Each of these microscopes had in its main focus a pair of cross-wires set in the form of an X; in one these wires were stationary,

* P. Kelly, LL.D., *Metrology*, London, 1816, pp. 57, *et seq.*

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but in the other they were attached to a rack which was movable laterally in the direction of the length of the rule b, by a micrometer screw, by means of which .0001 of an inch could be measured.* The method of observation followed by Hassler in making similar comparisons was to lay down the two scales on a perfectly level table, set the microscopes so as to coincide as nearly as practicable with the theoretical length of the standards to be measured, determine experimentally the exact value of a revolution of the micrometer screw, then remove the scale, place the standard under the microscope, adjusting it so that the cross-wires in the microscope without the micrometer exactly coincide with one of its defining points, then by means of the micrometer screw move the cross-wires in the other microscope until they exactly coincide with the other defining point; take the reading of the micrometer and from that determine the relation of the standard to the scale. The temperature is constantly observed by means of several thermometers lying on the scales and standards, and the readings corrected accordingly. In measuring end-standards metal butting-pieces have to be placed at their ends so as to give a sharp line of demarkation to be seen in the microscope, and standards of different thickness than the standard scale have to be brought into the focus of the microscope by the use of strips of wood to raise them up. The results obtained by Shuckburgh are shown in the following table:†

	Year.	Inches.
Standard yard of Henry VII.,	1490	35.924
" " Elizabeth,	1588	36.015
" " Guildhall,	1660	36.032
" " Clockmakers' Co.,	1671	35.972
Yard of Rowley's Tower Standard,	1720	36 004
" Graham's Scale by Sisson,	1742	36.0013
" " " " in the Exchequer,		35.9933
General Roy's Scale, made by Bird,	1745–60	36.00036
Mr. Aubert's Scale, " " "		35.99880
Royal Society's Scale, " " "		35.99955
Bird's Parliamentary Standard,	1758	36.00023
" " "	1760	36.00002‡

* Chisholm, *ibid.*, pp. 82, *et seq.* *Philosophical Transactions of the Royal Society of London*, 1798, 88, p 133 *et seq.* The above description is taken from Hassler, who used a comparateur of exactly the same construction as Shuckburgh's.

† Ferd. Rod. Hassler, "Comparison of Weights and Measures of Length and Capacity," reported to the U. S. Senate in 1832, Washington, 1832.

‡ S. C. Walker, *Jour. Frank. Inst.*, 17, New Ser. 13, p. 98.

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The standard yards constructed by Bird in 1758 and 1760 were left in the custody of the clerk of the House of Commons and finally adopted as the legal British standard by an act passed June 17, 1824, after another series of comparisons and measurements extending from 1816 to 1824, conducted mostly by Captain Henry Kater, who used Shuckburgh's scale and comparateur. He determined the relation between Shuckburgh's scale and the "Imperial yard" to be as 36 to 36.00018, and on a second determination 36 to 36.00009.* This act, 5th Geo. IV., ch. 74, went into effect January 1, 1826; it prescribes as follows:

"SECTION I. Be it enacted . . . . that . . . . the straight line or distance between the centres of the two points in the gold studs in the straight brass rod, now in the custody of the clerk of the House of Commons, whereon the words and figures 'Standard Yard 1760' are engraved, shall be and the same is hereby declared to be the extension called a yard; and that the same straight line or distance between the centres of the said two points in the said gold studs in the said brass rod, the brass being at the temperature of sixty-two degrees by Fahrenheit's thermometer, shall be and and is hereby denominated the Imperial Standard Yard.

"SEC. III. And whereas, it is expedient that the said standard yard, if lost, destroyed, defaced, or otherwise injured, should be restored to the same length by reference to some invariable natural standard; and whereas, it has been ascertained by the Commissioners appointed by His Majesty to inquire into the subject of Weights and Measures, that the yard hereby declared to be the Imperial Standard Yard, when compared with a pendulum vibrating seconds of mean time in the latitude of London in a vacuum at the level of the sea, is in the proportion of thirty-six inches to thirty-nine inches and one thousand three hundred and ninety-three ten thousandth parts of an inch; Be it therefore enacted, and declared, That if at any time hereafter the said Imperial Standard Yard shall be lost, or shall be in any manner destroyed, defaced, or otherwise injured, it shall and may be restored by making a new standard yard, bearing the same proportion to such pendulum as aforesaid as the said Imperial Standard Yard bears to such pendulum."†

* Walker, *ibid.*

† As quoted by George M. Bond, "Standards of Length and their Subdivisions," *Journal Franklin Institute*, 117-3 ser. 87, p. 285.

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"Just ten years afterwards, October 16, 1834, occurred the calamity for which the carefully-worded text of Section III. was intended to provide; a contingency certainly most wisely considered. This was the destruction of the Standard Yard by fire, when both Houses of Parliament were burned. The bar was recovered, but in a damaged condition, and all hopes of restoring its usefulness were abandoned when it was found that one of the gold plugs had been melted out."*

In 1838, a committee of scientific men was appointed by Parliament to consider the question of the restoration of the standards; they made a report in December, 1841, and in 1843 were appointed a commission to restore the lost standards.

In their report, they declared it to be their opinion that the course prescribed in the act would not reproduce the lost standard yard, as it had been conclusively proved, since the passage of the act, that there were errors in the determination of the specific gravity of the pendulum employed; the reduction to the sea-level had been shown by Dr. Young to have been doubtful; the reduction for the weight of air was also proved erroneous; and Kater had shown that sensible errors had been introduced in comparing the length of the pendulum with Shuckburgh's scale, which had been compared with Bird's "Standard Yard 1760," and found to agree closely. They had ascertained that several measures existed which had been most carefully compared with the Imperial Standard Yard, and expressed the opinion that by the use of these the standard could be restored without sensible error.†

Sir Francis Baily was a member of the commission, and to him was intrusted the work of the restoration of the yard. He made a large number of experiments to determine the best material of which to make the new standard, and finally selected an alloy since known as Baily's metal. It consists of 16 parts copper, 2½ tin, and 1 part zinc. Sir Francis Baily died in August, 1844, and the completion of the work was allotted to Rev. R. Sheepshanks, another member of the commission; he constructed a provisional brass rod as a "working standard," which he called "Brass No. 2," and which he compared with all the standards deemed sufficiently accurate for the purpose. He made use of Shuckburgh's scale, using two parts, from 0 to 36 inches, and from 10 to 46

* Bond, *Ibid.*, pp. 285-6.

† Bond—Chisholm.

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inches, which Captain Kater had considered the most accurate part of the scale; a yard of the Royal Society, constructed by Kater in 1831; and two iron bars belonging to the Ordnance Department, which had been compared with the Imperial Yard in 1834. The results obtained were as follows:

Brass No. 2 = 36.000084 of Shuckburgh's scale, 0–36 inches.
Brass No. 2 = 36.000280 of Shuckburgh's scale, 10–46 inches.
Brass No. 2 = 36.000229 of Kater's yard, 1831.
Brass No. 2 = 36.000303 of Ordnance yard, No. 1.
Brass No. 2 = 36.000275 of Ordnance yard, No. 2.
Brass No. 2 = 36.000234—by average of above.*

The Commission finally determined that "Brass No. 2" should be considered as equivalent to 36.00025 inches of the lost Imperial Standard Yard, at 62° F., and recommended the construction of the new standard yard on that basis. This was carried into effect by an act passed June 30, 1855, 18 and 19 Vic., ch. 72, which also repealed the section of the act of 1824 prescribing the method of reproduction of the standard from its relation to the seconds pendulum, which had been found to be inaccurate.

The standards were deposited in the office of the Exchequer, and in 1866 were placed in the custody of the Standards Department of the Board of Trade under the Warden of the Standards. The most important action in relation to British standards of length in recent years has been the recommendation made in 1870 "that mural or public standards of length be securely fixed for public use in all populous towns" where they would be readily accessible for comparison to persons desiring to use them. Under this recommendation measures of 100 feet and 66 feet were laid down on bronze blocks set in granite on the north side of Trafalgar Square in London and legalized as secondary standards by an order in council of June 27, 1876.† The errors of the 100-feet line, as determined by the Standards Department, are as follows:

At	0,	10,	20,	30,	40,	50,	60,	70,	80,	90,	100 feet.
Error	0	—.007	—.019	—.022	—.015	—.008	—.007	+.011	+.021	+.017	—.008 inches

The mean uncertainty in these values is .003 and the greatest uncertainty .01. The total length of the chain standard is —.019 inches from the truth.‡

(To be continued.)

* Chisholm, p. 87.

† W. S. Woolhouse, *Measures, Weights and Moneys of All Nations*, London, 1881, pp. 22, *et. seq.*

‡ Petrie, *Encyc. Brit*, xxiv., p. 480.

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THE CALCULATION OF LEAD BLAST-FURNACE CHARGES.

By H. VAN F. FURMAN, E.M.

The calculation of a lead blast-furnace charge is a more or less complex problem, owing to the many different points which have to be taken into consideration. Consideration must be given to the following:

First.—The charge must be calculated so as to produce a slag which will be good from both a metallurgical and an economic standpoint. A good metallurgical slag is one which is fusible, is adapted to the ores to be treated, should keep the furnace in good condition, should allow of a good separation of matte and speisse from the slag, and should be low in both lead and silver. An economic slag is one which will fulfil the above conditions and at the same time allow an economic mixture of the ores to be treated and require a minimum amount of costly flux. For example, at the present smelting centres of the West the majority of the ores received are dry silicious ores, and these are the ores in which there is the largest margin of profit. Lead, iron and lime are necessary fluxes which have to be added to the charge to produce the proper amount of bullion and the proper slag, and these fluxes are more or less costly as they have to be purchased at a price which allows little or nothing for smelting, and for every pound of flux added to the charge one pound less of ore, in which there is a profit, can be added. The amount of time, fuel, labor, etc., expended in smelting a pound of flux is the same as that expended in smelting a pound of ore. The following table gives the different type slags which are good metallurgical slags:

Table of Type Slags.

Notation.	SiO^2. Per cent.	FeO. Per cent.	CaO. Per cent.	ZnO. Per cent.
A.....	35	28	28	.....
B.....	34	34	24	.....
C.....	34	34	17	7
D.....	30	40	20	.....
E.....	30	48	12	.....
F.....	28 to 30	54	6	.....

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Slag A is a good slag which has been used in Utah and elsewhere for several years. It is especially adapted to ores carrying considerable alumina. This slag cannot be successfully made with impure ores having a high percentage of zinc.

Slag B is a favorite slag with Utah smelters, and is one of the best slags which we have, being more fusible and driving faster than A. This slag is not adapted to ores containing high percentages of zinc.

Slag C is a favorite type with Colorado smelters, as it runs well with high zinc charges, which is generally the rule in Colorado. As the per cent. of zinc on the charge decreases the per cent. of lime is raised, the slag more nearly approaching type B in composition. Types B and C really belong to the same general type, and are very similar in many of their physical properties.

Type D is a most excellent slag, generally known as "the half slag." This slag was formerly much used by Colorado and Utah smelters, but owing to the scarcity of iron in the ores of late years it is seldom used now.

Slag E is what is generally known as "the quarter slag," and was much used in the early days of smelting in Utah and Leadville when the ores were generally oxidized ores carrying a high per cent. of ferric oxide. It is a most excellent slag and answers all metallurgical purposes, but can only be run in exceptional cases owing to the prevailing scarcity of iron in the ores.

Slag E is not as good a slag as any of the foregoing, and is only to be recommended in certain rare and isolated places where there is a large excess of iron in the ores, and silicious ores are not available.

In all of the above types the sum of the SiO_2, FeO and CaO is considered as making about 90 per cent. of the slag constituents. This will be found to be the case except when the ores contain much ZnO and Al_2O_3, MnO being considered as FeO and MgO and BaO as CaO. Up to certain limits MnO will satisfactorily replace FeO, and the same may be said of MgO and BaO as regards CaO. Too much MnO (above 7 per cent. or 8 per cent.) seems to have a tendency to carry silver into the slag and too much MgO or BaO (above 4 per cent. or 5 per cent. in high lime slags) has a tendency to render the slags more infusible and pasty, and is liable to cause trouble in the furnace.

Second.—The charges must be calculated with regard to the

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ore supply on hand and what may be expected from the daily receipts of ore; that is, the products of the roasting and fusing furnaces, and the raw smelting ore coming to the works, must be used in about the proportions in which they exist, so as to not have a surplus of certain ores or products on hand. Hence, the metallurgist must keep posted as to the condition of the ore market, and the ore buyer must keep posted as to the requirements of the metallurgist.

Third.—The charge must not only be so calculated that we will have a sufficient amount of lead on the charge, but also so that the bullion will be of the proper grade. In the early days of smelting in this country a 20 per cent. lead-charge was not unusual, while, at the present time, a 12 per cent. charge may be stated as the average charge. As low as a 6 per cent. lead charge has been successfully smelted, but for good work, on fairly high-grade bullion, 10 per cent. may be considered as the limit. A charge of over 12 per cent. is rarely permissible in the Western smelting centres on account of the scarcity of lead and its high cost as a flux. The grade of the bullion must be taken into account, as, for example, some refiners will not pay for gold in the bullion if it is less than 1 ounce per ton, and gold ores are frequently scarce. The smelters generally pay for 95 per cent. of all the gold in ores which assay over 0.1 ounce per ton. Also on account of freight rates and refining charges, many smelters are required to keep the silver contents of the bullion within rather narrow limits, as, for example, not below 250 nor above 300 ounces per ton. Account must also be taken of the silver and lead losses in smelting, the amount of silver and lead which goes into the matte, and the amount of silver and lead which goes into the flue-dust, in determining the amount of bullion which should be produced. No exact rule can be given for determining these points, as they will differ according to the individual practice of the works, and can only be settled by the actual results at any particular works.

Fourth.—In addition to the slag and bullion-making elements present in the charge, we have such elements as sulphur and arsenic, part of which elements goes to make matte and speisse (a small amount also passing into the bullion) and part is volatilized in the furnace. The composition of pure iron matte is FeS, but, as the furnace-matte invariably contains Cu, Ag, Pb, Zn, and other constituents of the charge, its composition is varia-

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ble. The composition of speisse varies from Fe_5As to Fe_7As when pure; but it almost always contains Cu, Co, Ni, etc. Hence, no exact rule can be given for the allowance of iron to be made for the sulphur and arsenic on the charge. Just what the composition of the matte and speisse will be, and what the loss of sulphur and arsenic will be, will depend on the character of the ores under treatment and the working of the furnace. These points can only be determined by actual practice in each individual case. A rule which answers very well (until a more reliable one can be formed based upon the actual results from the working of the furnace) is to allow sufficient iron to convert one-half of the sulphur on the charge into FeS. For arsenic, allow sufficient iron to convert all the arsenic on the charge into Fe_5As. As the smelting of sulphide and arsenical ores is now usually preceded by roasting, the amount of S or As on the charge will not be very large.

In the case of ores containing copper, which is almost always present, the charge must contain sufficient sulphur to convert all of the copper into matte, as otherwise there will be trouble with the lead-well and hearth of the furnace.

Fifth.—The size of the charge and the amount of fuel must be taken into consideration. The size of the charge will depend, to a great extent, upon the size of the furnace. A usual charge is from 700 to 1000 pounds—the latter being a very convenient ore-and-flux charge for a modern, large-sized blast-furnace. In making up a charge, the total weight will frequently run under or over the weight which is desirable, but, as the question is simply one of proportion, the desired total weight can be obtained by increasing or reducing the weight of each ore, the limestone, etc., by 0.1, 0.2, or whatever proportion will give the desired weight. The weight of fuel to be used will depend upon the character of the charge, the fusibility of the slag, the altitude of the place at which the smelter is situated, the character of the coke and charcoal, and the dimensions of the furnace. The fuel is usually spoken of as such a per cent. of fuel, which per cent. may vary from 12 to 24. This per cent. is such a per cent. of the total weight of the ore and flux exclusive of whatever slag, from previous operations, may be on the charge, unless the amount of slag is large, when some fuel must be allowed for it. The amount of sulphur on the charge will affect the fuel-charge, as some of the sulphur will act

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as a fuel. The amount of lead will also affect the amount of fuel necessary, as high lead-charges will require considerably less fuel than low lead-charges. As an example of the effect of altitude, at Leadville (10,000 feet above sea-level) from 20 to 22 per cent. of fuel is necessary, whilst at Denver (5000 feet above sea-level) 15 to 17 per cent. is the usual charge, the ores and fuels in both cases being practically the same. The character of the fuel will make a considerable difference, as, if the coke is poor and friable there will be considerable waste in handling, and in the furnace, for which allowance must be made. The amount of ash which the fuel contains and its composition will also have to be taken into consideration. In the winter, when the coke is apt to be damp from snow and rain, allowance must be made for the moisture by allowing an increased weight of coke.

The above percentages of fuel are based upon a good, hard, dry coke, containing about 10 per cent. of ash, which contains from 55 to 65 per cent of silica. High lime-slags, and especially those which contain much baryta, will require a slight increase in the per cent. of fuel.

From the above it will be seen, that to calculate a charge the first step is to assume the different ores and their amounts which we will have on the charge, due consideration being given to the above points when making this assumption. The second step is to find the total amounts of silica, ferrous oxide, lime, etc., in the weights of ore as assumed, which is accomplished by multiplying the weight of each ore by its per cent. of silica, ferrous oxide, etc., and taking the sum of the different weights; a convenient way being to tabulate the results as illustrated in the examples.

If we assume the following notations for the totals and percentages: A = pounds of SiO_2 in the ores (total); B = pounds of FeO in the ores (total); C = pounds of CaO in the ores (total); d = per cent. of SiO_2 which the iron-ore (iron-flux to be added) contains; e = per cent. of SiO_2 which the limestone (lime-flux to be added) contains; f = per cent. of FeO in the iron-ore; l = per cent. of CaO in the limestone; X = pounds of iron ore required, and Y = pounds of limestone required, we have for slag A:

$$\frac{28}{35}(A + Xd + Ye) = B + Xf,$$

or,

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$$\frac{4}{5}(A + Xd + Ye) = B + Xf, \quad . \quad . \quad . \quad (1).$$

and

$$C + Yl = B + Xf, \quad . \quad . \quad . \quad . \quad (2).$$

Solving equation 2 with respect to Y, we have:

$$Y = \frac{B + Xf - C}{l} \quad . \quad . \quad . \quad . \quad (A').$$

Substituting this value of Y in equation 1, we have:

$$\frac{4}{5}\left(A + Xd + \frac{Be + Xef - Ce}{l}\right) = B + Xf.$$

Reducing and transposing, we have:

$$5Xfl - 4Xef - 4Xdl = 4Al + 4Be - 4Ce - 5Bl.$$

Solving with respect to X, we have:

$$X = \frac{4Al + 4Be - 4Ce - 5Bl}{5fl - 4ef - 4dl} \quad . \quad . \quad . \quad (A).$$

For slag B, we have,

$$A + Xd + Ye = B + Xf \quad . \quad . \quad . \quad (1).$$

$$\frac{24}{34}(B + Xf) = C + Yl \quad . \quad . \quad . \quad (2).$$

Solving equation 2, with respect to Y, we haye,

$$Y = \frac{12\,B + 12\,Xf - 17\,C}{17\,l} \quad . \quad . \quad . \quad (B').$$

Substituting this value for Y in equation 1, reducing and solving, we have,

$$X = \frac{17\,Al + 12\,Be - 17\,Ce - 17\,Bl}{17\,fl - 12\,ef - 17\,dl} \quad . \quad . \quad (B).$$

In like manner we obtain, for slag C,

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$$X = \frac{2\,Al + Re - 2\,Bl - 2\,Ce}{2\,fl - ef - 2\,dl} \quad . \quad . \quad . \quad \text{(C)}.$$

$$Y = \frac{B + Xf - 2C}{2\,l} \quad . \quad . \quad . \quad . \quad \text{(C')}.$$

and in like manner for slag D,

$$X = \frac{4\,Al + 2\,Be - 3\,Bl - 4\,Ce}{3\,fl - 2\,ef - 4\,dl} \quad . \quad . \quad \text{(D)}.$$

$$Y = \frac{B + Xf - 2\,C}{2\,l} \quad . \quad . \quad . \quad \text{(D')}.$$

and in like manner for slag E,

$$X = \frac{8\,Al + 2\,Be - 5\,Bl - 8\,Ce}{5\,fl - 2\,fe - 8\,dl} \quad . \quad . \quad \text{(E)}.$$

$$Y = \frac{B + Xf - 4\,C}{4\,l} \quad . \quad . \quad \text{(E')}.$$

and in like manner for slag F,

$$X = \frac{9\,Al + Be - 5\,Bl - 9\,Ce}{5\,fl - 9\,dl - fe} \quad . \quad . \quad \text{(F)}.$$

$$Y = \frac{B + Xf - 9\,C}{9\,l} \quad . \quad . \quad . \quad \text{(F')}.$$

In like manner general equations may be deduced for any type of slag which is desired to make.

Having obtained the above formulas it is only necessary to substitute for A, B, C, D, etc., their proper equivalents in the first formula to obtain X. Having obtained X, substitute its value, together with the proper equivalents of B, f, C and l, in the second formula to obtain Y.

The calculation of a charge is best illustrated by the following examples:

Example No. 1.—We have 50 tons per day of fused ore, 80 tons per day of roasted ore and matte, a bed of 2000 tons of ore which it is desirable to smelt in about two weeks and a supply of silicious silver-ore which it is desirable to smelt as rapidly as possible.

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In addition we have a regular supply of iron-ore, limestone and coke. The analyses of the ores are as follows:

	Per ct. SiO_2.	Per ct. FeO.	Per ct. CaO.	Per ct. Al_2O_3.	Per ct. Zn.	Per ct. Cu.	Per ct. Pb.	Per ct. S.	Ozs. pr T. Ag.	Ozs. pr T. Au.
Fused....	30	30	.....	.....	8	.....	15	3	50.0	1.00
Roasted	10	30	.....	.....	8	6	20	5	40.0	0.50
Bed.....	28	21	4	4	5	.....	21	2	55.0	0.50
Silver...	90	6	.....	.....	.....	.....	.....	.....	100.0	.....
Iron ore	10	75	.....	.....	.....	.....	.....	.....	.....	.....
Limestone..	5	.....	50	.....	.....	.....	.....	.....	.....	.....
Coke*...	5	.....	2	3	.....	.....	.....	.....	.....	.....

* Ash — 10 per cent.

Suppose we assume that we will smelt the ores in the same proportions as we have them on hand and smelt 50 pounds of silicious silver-ore per charge, and use 150 pounds of coke for a 1000 charge. A convenient method is to tabulate the results as follows:

Ore.	Lbs. per charge.	Lbs. SiO_2.	Lbs. FeO.	Lbs. CaO.	Lbs. Al_2O_3.	Lbs. Zn.	Lbs Cu.	Lbs Pb.	Lbs S.	Ozs. Ag.	Ozs. Au.
Fused...	100	30.	30	...	.....	8.	...	15	3	2.50	0.05
Roasted	160	16,	48	...	.....	12.8	9.6	32	8	4 20	0.04
Bed.....	300	84.	63	12	12	15.	...	63	6	8.25	0.045
Silver...	50	45.	3	...	.....	...	...	...	....	2 50	.....
Coke....	150	7.5	.....	3	4 5	...	...	....	....	.....	.....
Total..	760	182.5	144	15	16.5	35.8	9.6	110	17	17.45	0.135

Calculating one-half of the sulphur to Cu_2S and FeS, we have:

126.8 (mol. wt. of 2 Cu) : 158.8 (mol. wt. of Cu_2S) : : 9.6 (lbs. Cu) : x (lbs. of Cu_2S); $x = 12$. Hence $12 - 9.6 = 2.4$ lbs. of S which the Cu present will take up. Now $\frac{17}{2} - 2.4 = 6.1$ lbs. S to be taken up by Fe. Hence:

32 (at. wt. S) : 88 (mol. wt. FeS) : : 6.1 : x (lbs. of FeS which will be produced by excess of S); $x = 16.7$. Hence $16.7 - 6.1 = 10.6$

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lbs. of Fe necessary to take up excess of S. The following gives the amount of FeO to be deducted from the total pounds of FeO on the charge on account of sulphur, $10.6 \times \frac{9}{7} = 13.6$, and $144.0 - 13.6 = 130.4$ lbs. of FeO available.

From an inspection of the above totals slag "C" appears to be an economical and good slag to make. Substituting in equations C and C′ we have:

$$X = \frac{(2 \times 182.5 \times .5) + (130.4 \times .05) - (2 \times 130.4 \times .5) - (2 \times 15 \times .05)}{(2 \times .75 \times .5) - (75 \times .05) - (2 \times .1 \times .5)} = 93.2$$

$$Y = \frac{130.4 \times (93.2 \times .75) - (2 \times 15)}{2 \times .5} = 170.3.$$

As some of the zinc is volatilized, some passes into the bullion and matte and some goes into the wall accretions of the furnace, it is necessary to assume what amount will pass into the slag. If we assume that 80 per cent. of the zinc passes into the slag as ZnO, we will have 35.6 pounds of zinc oxide available as slag-making material. In order to calculate the percentage composition of the slag, which will result from the above charge, it will be necessary to calculate the pounds of SiO_2, FeO, CaO, etc., in the weights of iron ore and limestone on the charge as determined above, and add these weights to the above weights of available SiO_2, FeO, CaO, ZnO and Al_2O_3 to obtain the total weight of slag-making material on the charge. Making this calculation, we have: 200.3 (pounds SiO_2) + 200.3 (pounds FeO) + 100 (pounds CaO) + 35.6 (pounds ZnO) + 16.5 (pounds Al_2O_3) = 552.7. As these elements will not make up the total composition of the slag, it always carrying S, Pb, etc., it will be necessary to assume what proportion of the slag it will make up. If we assume that these elements will make 97 per cent. (an assumption which will usually be very near the actual results) we will have:

$$SiO_2 = \frac{200.3 \times 97}{552.7} = 35.17 \text{ per cent.}$$

$$FeO = \frac{200.3 \times 97}{552.7} = 35.17 \text{ per cent.}$$

$$CaO = \frac{100 \times 97}{552.7} = 17.55 \text{ per cent.}$$

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$$ZnO = \frac{35.6 \times 97}{552.7} = 6.24 \text{ per cent.}$$

$$Al_2O_3 = \frac{16.5 \times 97}{552.7} = 2.89 \text{ per cent.}$$

Which shows the calculation to be nearly correct for the type of slag chosen. The amount of lead on the charge is usually spoken of as so many per cent., referring to the total ore and flux charge. The following is the calculation of the lead on the above charge:

$$\frac{110 \text{ (\textit{pounds of lead})} \times 100}{873.5 \text{ (\textit{pounds of ore and flux})}} = 12.6 \text{ per cent.}$$

In order to arrive at the amount of bullion and matte which should be produced and its assay value, it would be necessary to assume the following:

First.—The amount of the charge which will pass into the flue-dust. This will depend upon the amount of fine material on the charge, the pressure of the blast, the height of the furnace, and the condition and working of the furnace.

Second.—The losses in lead, silver and gold in smelting (by volatilization and in the slag). These will depend upon the character of the ores and composition of the slag and the working of the furnace.

Third.—The amount of lead, silver and gold which will pass into the matte. These will depend upon the character of the slag, the per cent. and character of the fuel and the working of the furnace.

All of these are variable, and will not only vary at different works, but will vary from time to time at any works, owing to the changes in the ores, the working of the furnaces, etc.

After a works has been in operation some time, reasonably close constants may be deduced for these variables from the actual results obtained in smelting.

In the above example, suppose we assume that 10 per cent. of the charge will pass into the flue-dust; that the silver loss in smelting is 3 per cent.; that the lead loss in smelting is 8 per cent.; that the gold loss in smelting is nothing (it is usually unnecessary to make any allowance for loss in gold, as a works will usually produce more gold than is purchased, owing to the fact that many

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of the ores contain small quantities of gold which are not taken into account, and other causes); that the matte will carry about 10 per cent. of lead and that the lead passing into the matte will carry with it the same proportion of silver and gold as the lead in the bullion contains. Then, if the Cu_2S, FeS and Pb make up 90 per cent. of the matte, we will have:

110 — 9 (loss in smelting) = 101 pounds of lead.

101. — 10.1 (amount passing into the flue-dust) = 90.9 pounds of lead.

17.45 — 0.5235 (loss in smelting) = 16.9265 ounces of silver.

16.9265 — 1.6927 (amount passing into the flue-dust) = 15.2338 ounces of silver; and 0.135 — 0.0135 = 0.1215 ounces of gold available for matte and bullion.

The composition of the matte will be Cu_2S, 12 pounds; FeS, 16.7 pounds; Pb, 3.6 pounds. Balance (10 per cent.), 3.6 pounds. Total = 35.9 pounds.

$$\frac{15.2338 \times 3.6}{90.9} = 0.6033 \text{ ounces Ag in matte.}$$

$$\frac{0.1215 \times 3.6}{90.9} = 0.00481 \text{ ounces Au in matte.}$$

The assay value of the matte in ounces per ton of 2000 pounds will be,

$$\frac{0.6033 \times 2000}{35.9} = 33.6 \text{ ozs. Ag and } \frac{0.00481 \times 2000}{35.9} = 0.27 \text{ ozs. Au.}$$

The following calculation gives the amount of bullion which should be produced and its assay value:

15.2338 — 0.6033 = 14.6305 ounces Ag in bullion, and
0.1215 — 0.00481 = 0.11669 ounces Au in bullion.

$$(90.9 - 3.6) + \frac{14.63 + 0.117}{14.58} = 88.34 \text{ lbs. of bullion,}$$

which should be produced. The assay value in ounces per ton of 2000 pounds will be,

$$\frac{14.6305 \times 2000}{88.34} = 331.2 \text{ ozs. Ag,}$$

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and

$$\frac{0.11669 \times 2000}{88.34} = 2.64 \text{ ozs. Au.}$$

The total pounds of ore and flux on the charge is 873.5. If we desire a 1000 pound charge this weight is too small by about 15 per cent. Increasing the weight of each ore, the iron-ore and limestone by 15 per cent. we have, for the charge, fused ore, 115 pounds; roasted ore, 184 pounds; bed, 345 pounds; silver-ore, 62.5 pounds; iron-ore, 107.2 pounds, and limestone, 194.9 pounds.

As it is usual to set the furnace scales only to every 5 pounds difference in weight, the charge would be:

	Pounds.
Fused ore,	115
Roasted ore,	185
Bed,	345
Silver-ore,	65
Iron-ore,	110
Limestone,	195
	1015
Coke (15 per cent. of 1015),	150

As the analyses are made on the dry ore, allowance must be made in making up the charge for the moisture which the ores contain. In the above example the only ores liable to contain sufficient moisture to require allowance for it are the bed and the iron-ore. Allowance would be made in the case of these two ores by adding such a number of pounds as the moisture determinations, made from time to time, show to be necessary.

Example No. 2.—Suppose we have the following ores:

Ore.	Tons on hand.	Per ct. SiO_2.	Per ct. FeO.	Pr. ct CaO.	Pr. ct. Al_2O_3.	Pr. ct. ZnO.	Pr ct. Pb.	Pr. ct. S.	Per ct. Cu.	Ozs. pr T Ag.	Ozs. pr. T Au.
A.....	600	25.0	20.9	5.0	5.0	6.0	20.0	3.0	.....	30.0	0.05
B.....	200	90.0	7.9	...	...	....	...	....	.....	100.0	0.50
C.....	200	15.0	30.0	...	3.0	10.0	15.0	6.0	5.0	20.0	0.50
D.....	Regular supply.	20.0	45.0	...	...	....	15.0	...	.....	8.0	.....
Limestone..	"	5.0	.....	50.0	...	....	....	...	.....	.....	.....
Iron ore	"	5.0	80.0	...	....	...	....	...	.....	.....	.....
Coke....	"	6.0	.....	...	4.0	....	...	...	.....	.....	.....

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If we smelt the ores in the proportions in which we have them on hand and use ore D for iron-flux, we have:

Ore.	Lbs. per Charge.	Lbs. SiO_2.	Lbs. FeO.	Lbs. CaO.	Lbs. Al_2O_3.	Lbs. ZnO.	Lbs. S.	Lbs. Cu.	Lbs. Pb.	Ozs. Ag.	Ozs. Au.
A.....	300	75	62.7	15	15	18	9	....	60	4.50	0.00750
B.....	100	90	7.9	...	....	....	....	...	.....	5.00	0.02500
C.....	100	15	30.0	....	3	10	6	5	15	1.00	0.02500
Coke..	150	9	.....	....	6	...	...	....	.....	.....	.....
Total	.....	189	100.6	15	24	28	15	5	75	10 5	0 0575

Calculating one-half the sulphur to Cu_2S and FeS, we have 86.2 pounds available FeO. Assuming that 80 per cent. of the ZnO passes into the slag and adding this to the CaO, we have for available combined CaO and ZnO 37.4 pounds. Substituting in equations B and B′, we have:

$$X=\frac{(17\times 189\times 0.5)+(12\times 86.2\times 0.05)-(17\times 37.4\times 0.05)-(17\times 86.2\times 0.5)}{(17\times 0.45\times 0.5)-(12\times 0.05\times 0.45)-(17\times 0.2\times 0.5)}=480.7$$

$$Y=\frac{(12\times 86.2)+(12\times 480.7\times 0.45)-(17\times 37.4)}{17\times 0.5}=352.2.$$

From the above we have 10.8 per cent. of lead on the charge, and allowing for a 10 per cent. lead loss and a 4 per cent. silver loss in smelting, the bullion should assay about 182.7 ounces of silver and 0.88 ounces of gold per ton of 2000 pounds.

Taking the sum of the pounds of ore and limestone on the charge we have a total of 1333 pounds, which is about 25 per cent. too much if we wish a 1000 pound charge.

Reducing the weights by 25 per cent. we have, for the corrected charge:

	Pounds.
Ore A,	225
Ore B,	75
Ore C,	75
Ore D,	360
Limestone,	265
	1000
Coke,	150

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Example No. 3.—Suppose we have assumed the number of pounds of several ores which we will smelt on a charge, and have figured out the total pounds of SiO_2, FeO, etc. The totals are as follows:

lbs. SiO_2.	lbs. FeO.	lbs. CaO.	lbs. Al_2O_3.	lbs. ZnO.	lbs. Cu.	lbs. Pb.	lbs. S.	oz. Ag.	oz. Au.
211	177	54.5	30.5	12.	7.5	111	17.5	19.25	0.1075

Assuming that one-half of the S passes into the matte as FeS and Cu_2S, we have 161.3 pounds of FeO available for slag. We have, for fluxing, iron-ore containing SiO_2 5 per cent., FeO 80 per cent.; and limestone containing SiO_2 5 per cent., and CaO 50 per cent. Slags A, B or D are all good slags for the above charge. If we prefer to run slag A, we have by substitution in equations A and A′:

$$X = \frac{(4 \times 211 \times 0.5) + (4 \times 161.3 \times 0.05) - (4 \times 54.5 \times 0.05) - (5 \times 161.3 \times 0.5)}{(5 \times 0.8 \times 0.5) - (4 \times 0.05 \times 0.8) - (4 \times 0.05 \times 0.5)} = 17.5$$

$$Y = \frac{161.3 + (17.5 \times 0.8) - 54.5}{0.5} = 241.6$$

Hence we would require 17.5 pounds of iron-ore and 241.6 pounds of limestone to flux the charge.

Example No. 4.—We have on a charge, before fluxing, a total of available pounds as follows: SiO_2 200, FeO 160, and CaO 40.

Iron-ore containing SiO_2 5 per cent. and FeO 75 per cent. costs $6 per ton. Limestone containing SiO_2 5 per cent. and CaO 50 per cent. costs $1.50 per ton. It requires 15 per cent. of coke to smelt the charge, and the coke costs $10 per ton of 2000 pounds.

What type of slag would be the most economical?

Substituting in equations A, A′, B, B′, and D, D′, we obtain the following:

Slag A will require 15 pounds of iron-ore and 260 pounds of limestone. Hence the flux will cost $0.235 per charge, and the fuel necessary to smelt the flux will cost $0.206.—Total cost, $0.44.

Slag B will require 75 pounds of iron-ore and 260 pounds of limestone. Hence the flux will cost $0.3862 per charge, and the fuel necessary to smelt the flux will cost $0,225.—Total cost, $0.61.

Slag D will require 175 pounds of iron-ore and 52 pounds of

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limestone. Hence the cost of flux will be $0.559 per charge, and the fuel necessary to smelt the flux will cost $0.1688.—Total cost, $0.73.

With labor and general expense at $1.25 per charge, slag B would have to drive 13 per cent. faster than slag A, and slag D would have to drive 9.6 per cent. faster than slag B, and 23 per cent. faster than slag A to be as economical, other conditions being equal.

COMPARISON OF COST OF ELECTRIC LIGHTING OF COLUMBIA COLLEGE BY SEPARATE PLANT AND BY CONTRACT WITH COMPANIES.

By W. W. REESE and ARCHIBALD ANTHON.

Many of the large buildings in this city, and, in fact, all over the country, now have their own electric-lighting plants. The fact is, that in a large building where boilers, engines, and engineers, are indispensable for heating, pumping, and running of elevators, electric lighting furnished by dynamos run from the same boilers is very economical. This has been quite generally realized for a number of years; but exactly how much money is saved by having our own plant over what it would cost if the lamps were fed by currents supplied from some central-station electric lighting company, is a problem which few persons have taken the trouble to solve.

For several years, a portion of the buildings of Columbia College have been lighted by electricity; and, during the last nineteen months, almost exclusively by its own plant. Now, if we compare what it cost the college for its electric lighting for a certain number of lamp-hours, before it used its own plant, with what it now costs for the same number of lights, the results obtained will be valuable, as the conditions in almost every large building, hotel, club, etc., are very similar to those in the case which we intend to illustrate as an example.

The plant in Columbia College consists, briefly, of two steam-engines, two dynamos, and the necessary conductors, switch-board, lamps, instruments, etc.

The engines are both rated at 36 horse-power; one made by

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Armington & Sims, and the other by J. E. Sweet ("straight-line" engine). The dynamos are of the Edison type, both 400-light machines. They have frequently easily carried, without injury, 240 ampères each.

By inspection of the company's bills for previous years, and the record kept by the engineer in charge of plant, it was found that the average load per year, at present, is about 175 ampères—225 for the four winter months, and 150 on an average for the remaining eight months.

Now, assuming 175 ampères as the average, we then find the cost of running the plant for the entire year at this load.

A special test of one boiler and one engine was made, the essential parts of which are tabulated below.

In this test the boiler was supplying steam for one electric-light engine and three pumping-engines. The engine developed an average of 36 indicated horse-power. Allowing for the amount of steam used by the pumping-engines, we find that 3.7 pounds of coal are burned per horse-power hour for the engine alone.

Since the average load per year is 175 ampères, at 118 volts, and the efficiency of transmission is 64 per cent., the engine will have to develop 43.25 horse-power. At 3.7 pounds of coal per horse-power hour, we have the total amount of coal consumed per hour as 160.02 pounds. The working-day is 17 hours, and there are 309 working days in the year; this gives 5253 hours per year, and at 160.02 pounds of coal per hour the total amount consumed per year is 840,585.06 pounds, or 375.2 long tons. At $2.75 per ton the cost of coal is $1031.80 per year.

The cost of the two dynamos was $2000; the engines, settings, belts, etc., about $1500; and the wiring, $1500; making a total first cost of $5000. Allowing 15 per cent. interest, depreciation, and repairs (very liberal under good management), this amounts to $750 per year.

Test of Water-Tube Boiler, Manufactured by Babcock & Wilcox Co.

Duration of trial, hours,	6.384
Steam gauge, pounds,	85
Absolute steam-pressure, pounds,	100
Total coal consumed, pounds,	2183
Actual evaporation per pound of fuel, pounds,	9.07
H. P. on basis 34½ pounds equiv. evap. per hour,	91.3
Efficiency of boiler, per cent.,	67.4

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Test of Armington & Sims' Engine, Running one Edison Dynamo.

	Head.		Crank.		Total.			
No.	M. E. P.	I. H. P.	M. E. P.	I. H. P.	I. H. P.	Volts.	Amp.	D. H. P.
1.....	30.5	17.87	31.7	18.2	36.07	.....	.....	.....
2.....	33.6	19.35	31.2	17.5	36.85	118.	169	26.78
3.....	25.71	14.82	26.9	16.8	31.62	116.	125	19.46
4.....	26.83	15.23	30.5	17.5	32.73	116.	132	20.5
5.....	26.5	15.51	28.86	16.45	31.55	116.5	132	20.7
6.....	28.8	17.25	31.2	18.2	35.45	116.	148	23.1
7.....	27.2	16.3	29.6	17.26	33.56	116.5	135	21.1
8.....	26 25	16.	28.78	17.1	33 1	117.	130	20.4
9.....	31.72	18.42	34.15	19.31	37.73	117.	155	24.3
10.....	28.5	16.95	29.88	17.22	34.17	117.	132	20.7
11.....	27.5	16.08	28.3	16.39	32.47	115.	139	21.45
12.....	26.8	15.93	30.48	17.64	33.57	116.	138	21.47
13.....	27.	16.06	29.5	17.08	33 14	116.	139	21.6
14.....	29.28	17.28	30.5	17.52	34.8	115.	150	23.12
15.....	29.5	17.4	31 9	18.33	35.73	117.	145	22.76
16.....	27.17	16.2	30.86	17.95	34.15	117.	141	22.1
17.....	28.5	17.	31.	18.02	35 02	115.	142	21.9
18.....	29.12	17.12	31.6	18.1	35.22	116.5	145	22.8
19.....	28.3	16.95	31.95	18 51	35.57	115.	152	23.42
20.....	31.85	18.59	34.3	19.5	38.09	118.	151	23.9
21.....	24.05	18.16	32.	18.45	36.61	118.	152	24 05
22.....	29.15	17.32	32.8	19.	36.32	116.	143	23.23
23.....	29.6	18.05	30.8	18.4	36.45	116.	158	24.6
24.....	40.01	23.2	40.01	22.61	45.81	115.	202	31.9
25.....	44.75	25.8	46.	25.83	51.63	115.5	215	33.3
26.....	45.02	26.01	46.38	26.02	52.03	118.	225	35.35

Average I. H. P ,.....36.51.
Average D. H. P.,.....23.40.
Efficiency of transmission,.....64 per ct.

One additional hand is required at wages of $70 per month, or $840 per year.

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It is estimated that the plant requires 108 gallons of cylinder oil, and 360 gallons of machine oil per year. Also, about 120 pounds of waste. $50 per year amply covers the water used by the engines of the plant.

Tabulating the above items, we have:

Interest, depreciation, and repairs, per year,	$750 00
Cost of additional labor, per year,	840 00
Cost of additional coal consumed, per year,	1031 80
Cost of 108 gallons of cylinder oil, at 55 cents per gallon,	59 40
Cost of 360 gallons of machine oil, at 30 cents per gallon,	108 00
Cost of water, per year,	50 00
Cost of waste, per year,	12 00
	$2851 20

This makes a total cost of $2851.20 for running the plant for the 919,275 ampère-hours.

The company's bills for the year previous to the installation of plant were as follows:

November,	$421 80
December,	437 55
January,	469 65
February,	557 85
March,	627 75
April,	380 00
May,	274 19
June,	288 88
July,	297 58
August,	341 77
September,	372 06
October,	421 34
	$4890 22

This makes the total cost of lighting by the Electric Light Company for one year, $4890.22. The price paid per lamp-hour was three-quarters of one cent. This makes the total number of lamp-hours per year, 652,029, or 326,014 ampère-hours.

Our present plant is, however, supplying light for an average of 919,273 ampère-hours per year, and at the above rate the Lighting Company would have charged $13,789.12. Now, as shown previously, this amount of light only costs the college $2851.20. Therefore the college saves $10,937.92 a year by having its own plant, thus decreasing the cost of lighting to about one-fifth of

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what it would otherwise be. That is, lighting costs, on a average, one-seventh of 1 cent per lamp-hour, as against three-quarters of 1 cent charged by the company.

If the college had to pay three-quarters of 1 cent per lamp-hour to the company, it would, of course, be necessary to economize, and not use as much light as is now supplied by its plant. But this would be just so much of a disadvantage, and it would certainly be necessary to have, at least, one-half as much light as we have now, which would cost $5500 against $2851.20, for abundance of light.

NOTES ON THE HUANCHACA MINE, BOLIVIA, S. A.

By ROBERT PEELE, Jr.

This great silver mine, by far the largest producer in South America, if not in the world, is situated at an altitude of about 13,400 feet, in a group of hills on the central table-land of Bolivia. It is connected with the port of Antofagasta, on the Chilean coast, by a 30-inch gauge railroad, 395 miles long, built through the influence, and largely by the capital, of the Huanchaca company.

The mine comprises workings on two main parallel and nearly vertical veins. These veins cut through a small mountain which reaches a height of about 14,500 feet above sea-level. Many years ago they were extensively worked to a depth of several hundred feet, but these operations were not successful as a whole; the veins were notable neither for quantity nor richness of ore, and even after a number of native capitalists became interested, and the work of exploration was pushed more vigorously, the future of the mine seemed extremely doubtful. No one imagined it was destined to pay millions in dividends.

During the past fifteen years the gross production has been worth, in United States currency, at least $46,000,000, of which about $15,000,000 has been paid to the stockholders.

According to the official report for 1891, there was still standing in the mine ore containing 15,300,000 ounces of siiver. The basis for this estimate, however, is not stated.

Until recently the mine has been worked according to the old

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Spanish-American methods, human labor to a large extent supplying the place of machinery. But during the past two years a very heavy and expensive plant has been erected, including two large hoisting-engines and an air-compressor. This machinery is supplied with steam by a battery of six boilers of 200 horse-power each.

The workings on January 1, 1892, had reached a depth of 1190 feet below the level of the main tunnel.

During 1891, according to the company's report, the gross product was 5,942,000 ounces silver, yielding a net profit of $2,050,000 United States currency. Of the total production, 17,193 tons of ore, containing 4,041,000 ounces silver were exported to Europe, and 13,890 tons, containing 1,894,800 ounces were treated in the amalgamation works near the mine.

The ore, after handsorting, assays from 120 to 300 ounces per ton, the higher grade being shipped. The cost of mining, handling, and sorting is about $28 per ton, that of milling, $24 per ton. Though these working expenses are rather high, it must be remembered that the situation of the mine is extremely unfavorable, far in the interior of the country, with inefficient labor and high freights.

The ore consists of a quartzose gangue, carrying iron and copper pyrites, galena, blende and tetrahedrite, the latter usually massive but sometimes beautifully crystallized. The tetrahedrite contains the greater part of the value of the ore, and is very abundant.

The following data I obtained in Huanchaca in 1891 :

Average Composition of the Sorted Ore.

	Per cent,
SiO_2,	23.00
Cu,	1.89
Pb,	11.30
Zn,	21.50
Fe,	11.60
S,	26.00
As,	0.35
Sb,	1.80

The ore is pulverized in Gruson ball mills made in Magdeburg, Germany, each mill grinding from 10 to 12 tons per 24 hours to 50 mesh. In these mills 130 pounds of ore are crushed per hour per horse-power.

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Roasting is now done in reverberatory furnaces, 11.5 feet × 55.5 feet, containing 3 step-hearths, fire-place 10 × 3 feet. These furnaces are worked from both sides, 2 shifts per 24 hours, 6 men on a shift for each furnace. Seven charges of 2000 pounds are roasted per 24 hours. Four per cent. of salt is added on the second hearth, and 25 pounds of fuel (consisting of small scrub-wood and brush) are required per 100 pounds of ore.

No attempt is made to chlorinate to a higher percentage than 50 per cent., from 47 to 50 per cent. being found by experience to give the best results in amalgamation. After drawing the roasted ore from the furnace, it is at once spread out on the cooling-floor to prevent further chlorination.

Losses in Roasting.

(Figures taken at random from the mill records.)

Values of Ore—Ozs.		Per cent Loss.
Raw.	Roasted.	
131.4	143.4	2.18
131.5	138.6	0.59
126.0	129.0	0.55
148.8	152.4	2.99

The apparent gain in value of the roasted ore is caused by the driving off of the sulphur. The actual loss in roasting is said to be from 3 to 5 per cent., showing careful and very satisfactory work.

The ore is amalgamated in large "tinas," similar to ordinary amalgamating pans, the charge being 5500 pounds; time, 4½ to 5 hours; charge of quicksilver, 120 to 160 pounds.

The results of amalgamation are shown in the following table, the values being given in percentages of silver, and the extraction calculated on the value of the roasted ore:

Roasted Ore.	Tailings.	Extraction.	Loss of Hg. in ozs. per oz. of Silver extracted.
0.455	0.036	92.09	0.32
0.452	0.042	90.71	0.42
0.464	0.029	93.75	0.21

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Retort-silver averages 990 fine; after melting into bars, 994.

The total losses, carefully averaged over a considerable length of time, are:

Loss in transportation and grinding,	1¼ to 2 per cent.
Loss in roasting,	3 to 5 per cent.
Loss in amalgamating,	8 to 10 per cent.
Loss in stealing amalgam,	$\frac{1}{10}$ of 1 per cent.
Loss in melting into bars,	$\frac{1}{10}$ of 1 per cent.

The net extraction varies from 82 to 87 per cent., which indicates remarkably good metallurgical work.

The mine is worked through a tunnel which cuts the veins about 1500 feet from the mouth. As the amalgamation works are 4½ miles distant, on the opposite side of the mountain, the cost of transportation was, formerly, a serious burden. Several years ago, the main tunnel was continued entirely through the mountain, making a total length of 10,750 feet. It is connected by a gravity-road with the reduction works.

Upon the dump of the mine there are between 60,000 and 70,000 tons of ore containing from 75 to 90 ounces silver per ton. This has accumulated in the absence of means to work it at a profit before the railroad was built; but, during the past three years, a large reduction works has been in process of erection on the seacoast near the railroad. The intention is to discard the present mill near the mine, and work all the lower-grade material at this new establishment, 395 miles from the mine.

NOTE ON EL CALLAO GOLD MINE, OF VENEZUELA.

By R. PEELE, Jr.

The following data on the famous "El Callao" gold mine, Venezuela, may be of interest to the readers of the QUARTERLY. They are extracted from the semi-annual report of the superintendent for the six months ending June 30, 1892:

Total ore hoisted, tons,	31,726
Total ore milled, tons,	31,059
Gold produced from the milling of the above ore, ounces,	19,743
Value of bullion, estimated at,	$379,072 00
Average milling value per ton, ounces,	0.63½
Average value for the year 1891, ounces,	0.58

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Cost of mining 31,726 tons,	$231,000 00
Cost of milling 31,059 tons,	32,900 00
General expenses,	34,660 00
Total,	$298,560 00
Sinking No. 7 shaft (dead work),	9355 00
Total expenses,	$307,915 00
Net profits for the six months,	$71,157 00
Total cost per ton, 1891,	10 03
Total cost per ton, 1892,	9 70

A new shaft, 135 feet deep, was sunk at a cost, including hoisting-works, of $9355, or $69.30 per foot. The size of this shaft, inside the lining timbers (8 by 8 inches) is 4 by 10 feet, and, to the present depth, is in soft decomposed material, which, perhaps, accounts for its rather high cost. Exclusive of the hoisting plant, the cost per foot was about $53.00.

NOTE ON THE ANALYSIS OF TIN ORE.

By J. S. C. WELLS, PhD.

In an article on the "Assay of Tin," by Mr. E. H. Miller (S. of M. Quart., July 1892), appears the following statement.

"Reduction by means of granulated zinc (Wells, S. of M. Quart., XII., 295) and hydrochloric acid was also tried, but without success, owing possibly to the omission of a piece of platinum foil, which is claimed to greatly assist in the efficiency of the reduction.

In the description of my method, I distinctly stated that some ores were only slightly acted on unless platinum was present. In order to see if Mr. Miller's failure was not due to this cause, I got from him a sample of the same ore that he used in his tests and treated it according to the method given by me, and found it to be easily reduced, yielding 64.12 per cent. of tin, a result agreeing very favorably with those obtained by him.

Further investigation of the method has shown that it is preferable to use strong hydrochloric acid instead of dilute, and in this case it is not necessary to heat, as the action of the acid on the zinc heats the solution sufficiently. A large excess of zinc should be used so as to have an abundant supply of hydrogen. The platinum I have added in the form of small pieces cut from a piece of old foil.

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ABSTRACTS.

Analytical Chemistry, by E. Waller, Ph.D.

Action of Water and Solutions on Glass. Foerster (*Berichte*, xxv., 2494), has continued researches on this subject. His conclusions are:

1. Solutions of caustic alkalies act much more strongly than does water, inasmuch as they dissolve *all* the constituents of the glass; in short, the glass itself (if we leave out of account the action of very dilute solutions).

2. Of the caustic alkalies, soda acts most strongly, then potassa, and, finally, ammonia and baryta water.

3. A rise in temperature increases very markedly the attack by alkalies.

4. With an increase in concentration of the alkaline solutions, the attack of the glass increases at first rapidly on raising the temperature, but after a time more slowly.

5. At ordinary temperatures, very concentrated alkaline solutions act more feebly upon glass than those more dilute.

6. Solutions of pure alkalies, if not too concentrated, act more feebly upon glass than such as are contaminated by small amounts of silicic acid.

7. Carbonated alkalies, even in very dilute solutions, attack glass much more strongly than does water. Their mode of action resembles less that of caustic alkalies that it does that of other salts. With equivalent concentration Na_2CO_3 solutions act more strongly than those of K_2CO_3.

8. The action of solutions of salts is variable, depending upon the degree of concentration, the nature of the dissolved salt, and the action of the water.

9. Both kinds of attack are variably influenced by the composition of the glass.

10. Of salts, those attack the most strongly (stronger than water), the acids of which form insoluble lime salts. With these, the action increases with the concentration.

Micrographic Analysis of Alloys. Guillemin (*Comptes Rend.*, 1892, cxv., 232), has examined many of the alloys used in the arts by etching a polished surface with diluted H_2SO_4, either alone or in conjunction with the electric current. The composition, character and mechanical treatment of the alloys may be decided by this means.

Keeping Permanganate Solutions. Gruzner (*Arch. Pharm.*, ccxxxi., 321), finds that solutions of 1 : 1000 kept their strength for a year in diffused daylight or in blackened glass bottles. After 18 months solutions of this strength kept in colorless glass in diffused daylight had lost by 2.61 per cent.; in blackened glass, loss = 0.94 per cent. Solutions of 3 : 1000 kept perfectly during the same periods and under the same conditions.

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Arsenious Acid for Volumetric Analysis. Namias (*Gaz. Chim. Ital.*, xxii., 508), prepares a solution by heating 8 gms. As_2O_3 with 80 gms. $NH_4C_2H_3O_2$ in 300 to 400 c.c. of water, finally cooling and diluting to one litre. NH_4Cl solutions dissolve As_2O_3, but deposit it partially by standing. The acetate solution can be used in examination of bleaching powder, of chlorates, of commercial MnO_2, chromates, etc.

Alkalimetric Indicator. Werner-Bolton (*Zts. Angew. Chem.*, 1891, 492), proposes the use of a drop of solution of an alkaline sulphide saturated with sulphnr. A permanent milky turbidity is produced by the least possible trace of acid in excess.

Potash Determination. Payne (*Bull. No. 35, of Association of Agric. Chemists*, Report for 1892), reports on the results obtained by several chemists in applying the Lindo-Gladding method—conversion of alkalies to sulphates, precipitation by $PtCl_4$ in presence of NaCl, washing with alcohol, then with water solution of NH_4Cl (saturated with $PtCl_4$), and finally, with alcohol. The conclusion reached is that the addition of NaCl is unnecessary.

Separating Zinc from Lime and Magnesia. Stone (*Jour. Anal. and App. Chem.*, vi., 516), has experimented on a method based upon the solubility of $ZnNH_4PO_4$ in ammonia. Separation can be effected in the cold and in presence of sufficient NH_4Cl. 25 to 50 c.c. of a solution containing 100 gms. NH_4Cl and 700 c.c. strong ammonia per litre are added, and then 1 c c. of a 10 per cent. solution of phosphorus salt for every 0.01 gm. of Zn assumed to be present. After the precipitate has settled, filter and wash with dilute ammonia. The filtrate is nearly neutralized with HNO_3, then rendered slightly acid with $HC_2H_3O_2$, and heated until the Zn NH_4PO_4 becomes crystalline, when it may be filtered off and treated as usual. The method is best adapted to solutions containing much Zn and little CaO and MgO. If much CaO and MgO are present, the precipitated phosphates should be redissolved in HCl, and reprecipitated.

The CaO and MgO may be separated by Chester's method (*Amer. Chem.*, 1876, 281), precipitation of the CaO in a boiling hot solution (containing a slight excess of free HCl) by means of $(NH_4)_2C_2O_4$.

Reaction of Ferric Salts with Sulphocyanates. Vernon (*Chem. News*, lxvi., 191, 202 and 214) concludes that dilution has a potent influence with solutions of ferric sulphocyanate on account of the dissociation which occurs. When a large excess, either of ferric salt or of alkaline sulphocyanate is present, the ferric sulphocyanate (color) is more stable On testing the color reactions obtained by the use on the one hand of various ferric salts, and on the other hand of alkaline and alkaline earth sulphocyanates, the proportion of ferric sulphocyanates produced was found to be proportional to the product of two constants; one depending upon the nature of the acid of the ferric salt; the other on the nature of the base of the sulphocyanate.

Heat increases the color obtained with ferric salts of monobasic acids, but diminishes the color with ferric salts of polybasic acids.

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Separation of Iron. Rothe (*Mitth. König techn Versuchsanst*, x., 132) describes a process depending upon the solubility of Fe_2Cl_6 in ether, Mn Cr, Ni and Al chlorides as well as $FeCl_3$ are not soluble under the conditions obtained. Those of Co and Cu are only slightly soluble, and may be removed from the ether solution by altering the conditions. In the case of iron and steel dissolve 5 gms. in HCl (Gr 1.124) evaporate to dryness and heat to 120° C. Redissolve in 20 c.c. of HCl, boil, dilute, filter off SiO_2. Concentrate to small bulk, add 10 c.c. HCl, and oxidize at a boiling heat by adding conc. HNO_3 drop by drop (about 2–2.5 c.c.) evaporate until basic chloride begins to separate. Then add 50 to 60 c.c. conc. HCl, and shake out twice with ether. If Cu or Co are present the small amounts taken up by the ether may be removed by shaking it with HCl of Sp. Gr. 1.04. The solution will contain Al, Mn, etc., as chlorides practically free from Fe.

Separating Ferric Oxide from Alumina in Phosphatic Rocks. Glaser (*Pharm. Rev.*, Oct., 1892 and *J. Anal. and App. Chem.*, vi., 524) describes his method. The HCl solution is nearly neutralized with ammonia, using methyl orange as indicator. $NH_4C_2H_3O_2$ is then added until the color changes to pale yellow. Heat to not over 70°C. until the (Al Fe) PO_4 has completely separated, filter and wash. Some CaO may come down with the first precipitate, so that it is well to redissolve and reprecipitate again, adding a little Na_2HPO_4 to the solution. After drying ignite (at not too high a temperature), in a weighed platinum crucible. Weigh, cover with dry Na_2CO_3 and fuse for about ten minutes. Cool, dissolve and melt in boiling water, filter out Fe_2O_3, dissolve it in HCl and precipitate by ammonia for weighing. In the water solution from the melt, acidify with HCl, boil out CO_2, add $NH_4C_2H_3O_2$ and precipitate Al PO_4 in the manner described above.

Manganese in Manufactured Iron. Von Reis (*Zts. angew. Chem.*, 1892, 604 and 672). Prepare a mixture of 275 volumes H_2O, 125 volumes HNO_3 and 100 volumes H_2SO_4. Treat 1 gm. of pig-iron, spiegel or ferro-manganese with 25 c.c. of this mixture in a porcelain dish. When solution has been effected, evaporate to SO_3 fumes, cool, dilute to about 100 c.c. add 10 c.c. of the acid mixture and heat until all salts are dissolved. Rinse into a litre Erlenmeyer flask, add about 3 gms. dry BaO_2 and 5 c.c. conc. HNO_3—boil two to three minutes to decompose the BaO_2. Then add 400 c.c. of water at a temperature of about 90° and a slight excess of ZnO. (It is noted that it is possible to add too much ZnO, in which case the precipitate assumes a reddish-brown tint). Titrate with standard permanganate (Volhard). For pig or cast iron the value of the permanganate should be 1 c.c. = 0.001 Mn.; for spiegel and ferro-manganese it should be 1 c.c. = 0.005 Mn. The arrangements for the standard solutions, burettes, etc., are minutely described.

Determination of Chromate. Perrault. (*Monit. Sci.*, 1892, 721). A "10 volume" solution of H_2O_2 is diluted ten times and standardized thus: 3 c.c. of a solution containing 37 gms. $K_2Cr_2O_7$ per litre are diluted to 1 litre. Of this 50 c.c. are neutralized with a 10 per cent. solution of ammonia, and 1.5 c.c. of 10 per cent. HCl added. The

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H_2O_2 solution is then run in until no more blue coloration ensues. The analysis is conducted by producing conditions essentially similar with the substance analyzed.

Nickel in Presence of Cobalt. Lafay (*Jour. Pharm. Chem.* [5], xxvi., 67). If one adds to a 5 per cent. solution of $CoCl_2$ (nearly neutral) an equal volume of conc. $K_2Cr_2O_7$ solution, and a large excess of ammonia, a precipitate immediately forms, which can be redissolved by addition of excess of 30 per cent. KOH solution. Nickel under the same conditions gives no precipitate with the ammonia, and a greenish-white precipitate with the KOH. The same reactions occur when the two metals are present in the same solution, and therefore affords a ready method for the detection of one in presence of the other.

Cyanide Separation of Nickel and Cobalt. Qualitative. Hambly (*Chem. News*, lxv., 28). Dissolve the sulphides in HCl + $KClO_3$, evaporate to remove excess of acid, neutralize and dilute, add an excess of KCy in cold water, make alkaline with NaOH, add about twice its volume of Br water, heat gently and filter off $Ni_2(OH)_6$. In the filtrate acidify with H_2SO_4, evaporate low, add ammonia and $(NH_4)_2S$, and test the precipitate with the bead.

Volumetric for Arsenic Acid. Franceschi (*L'Orosi*, xv. 192) uses a standardized solution of Fe_2Cl_6 with KCNS as indicator. The arsenic acid solution must be neutral, and free from acetate or phosphate. Insoluble arsenates must be decomposed with Na_2CO_3 and the solution neutralized with HCl before titrating. If phosphates are present, the arsenic must be separated as sulphide, and converted to arsenate. Conversely ferric salts may be titrated with alkaline arsenate, the end reaction being marked by decolorization of ferric sulphocyanate in the solution.

Rapid Precipitation of As_2S_5. Neher (*Fres. Zts. Anal. Chem.*, xxxii., 45) finds that precipitation is rapid in strong HCl solution (containing at least two volumes conc. HCl to one vol. of water). A rapid stream of H_2S must be passed for about 1½ hours. Care is necessary to avoid heating the solution, either before or during the passage of the gas. After filtering, the precipitate should be finally washed with hot alcohol to remove the traces of sulphur which may accompany it.

Detection, Etc., of Arsenic. Thiele (*Liebig's Annalen*, cclxv., p. 55) reports with regard to this subject. Hypophosphorus acid precipitates the element without boiling, in a solution strongly acidified with HCl. The addition of KI facilitates the reaction.

In the Marsh apparatus metallic iron may be used to precipitate Sb, allowing the As to escape as AsH_3. The iron, however, must be free from sulphide, or the As will not all be evolved.

The use of platinized zinc in the Marsh apparatus diminishes the delicacy of the test. A rapid current of H_2S precipitates As_2S_5 from a warm acidified solution of H_3AsO_4. A slower stream gives a mixture of As_2S_3, As_2S_5 and S. The same thing occurs in the cold if the solution is strongly acidified with HCl, also when the gas is diluted but passed

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in a rapid current through a warm acidified solution. The reduction to H_3AsO_3 by concentrated acid as described by Mayrhofer was not found to occur. A description is given of the method for obtaining and determining all the As in a substance, evolving it as AsH_3.

Determination of Antimony. Paul (*Zts. Anal. Chem.*, xxxi., 537) precipitates as sulphide (tri- or penta-) and filters through a Gooch crucible with asbestos bed. He then adds sulphur (flowers) and heats for some time in 200–230° C. in a current of CO_2, which affords Sb_2S_3. A special form of apparatus for the purpose has been designed by the author.

Detection of Gold. Rose (*Chem. News.*, lxvi., 271) gives a method of applying the purple of cassius test, which he has found to be exceedingly delicate. The solution (which may contain only 1 part Au. per hundred million) is brought to boiling, and then quickly poured into 10 c.c. of a saturated solution of $SnCl_2$ in such a way as to mix the liquids as rapidly as possible. The color will at once develop.

Determination of Lead. Medicus (*Berichte*, xiv., 2490) converts the lead to chloride, dissolves that in KOH, and then precipitates by passing CO_2 for a couple of hours. The precipitate is filtered off, washed and dissolved in HNO_3, and precipitated electrolytically as PbO_2. It was also found possible to precipitate as PbO_2 from the KOH solution above mentioned, by passing a slow current of Br gas.

Detecting Lead in Presence of Copper and Iron. Feed (*Analyst*, xvii., 142). In beverages, etc., where these metals may be present in small quantities $(NH_4)_2S$ is a delicate reagent. This, however, does not distinguish between Pb and Cu unless KCy is added, when a dark coloration is due to Pb only, the CuS being soluble in cyanide.

Titration of Thallium. Spenholz (*Zts. Anal. Chem.*, xxxi., 519) proposes to titrate thallious salts with standardized solutions of bromine water. The end reaction is a yellow color in the solution from excess of Br. Two atoms Br. oxidize 1 atom Tl. to the thallic form.

Electrolytic Separations. Smith and Wallace. (*Jour. An. and App. Chem.*, vi., 87). In KCy solutions Au is readily separated from As, Mo or Os, also from W if WO_3 is dissolved up in KCy. If, however, the WO_3 isdissolved in KOH and KCy is added, the separation is unsatisfactory. Cd, Ag or Hg are readily separated from Os in a KCy solution. Cd is separable from Ni and KCy solution if KOH is present. If, however, only KCy was present no separation was effected.

Electrolytic Separations. Rudorff (*Zts. angew. Chem.*, 1892, 695). Classens' methods with oxalates were not found to be so convenient as claimed in many cases. In these experiments Meidinger cells were used, and 10 to 12 hours were allowed for most of the precipitations.

Au was separated 0.1 to 0.3 gm. from 120 c.c. of solution containing 2–3 gms. KCy, by the use of 2–3 cells.

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Pt, 0.1 to 0.5 gms. separated from 120 c.c. of solution, acidified with H_2SO_4 by 2 cells.

Ag separated from Cu, where the combined weight of both metals was 0.5 gm. or less. Solution 122 c.c. containing 8 gms. KCy if the Ag predominated, or 12 gms. KCy if the Cu predominated. 2 to 3 cells. The solution was then evaporated with H_2SO_4 to expel HCy, and electrolyzed after addition of 3 gms. NH_4NO_3 and 20 c.c. ammonia (Gr. 0.91).

More rapid work could be obtained by precipitating Ag by NaCl, and separating only the Cu by electrolysis after addition of ammonia and nitrate as above, using 3 to 5 cells.

Hg from Cu (combined metals 0.4 gm. or less), electrolyze (120 c.c.) solution containing 6 gms. KCy if Hg predominates, or 10 gms. KCy if Cu predominates. Separate Cu from the solution as in the case just cited.

Cd from Cu (combined metals 0.5 gm. or less). Divide in halves. In one half add 2 c.c. HNO_3 and precipitate Cu. To the other half add 12 gms. KCy and electrolyze out Cd, 2–3 cells in each case.

Cu from Ni (combined metals 0.4 to 0.5 gm). Add 1 c.c. HNO_3 first and precipitate Cu (2–3 cells) in 120 c.c. Then add 2 c.c. of a saturated solution of $NaC_2H_3O_2$, pour off the liquid, rinse, evaporate to half the original bulk, add 20 c.c. of saturated solution of $(NH_4)_2SO_4$ and 25 c.c. ammonia and precipitate out Ni by 4 to 6 cells.

Electrolytic Separation of Copper. Drossbach (*Chem. Ztg.*, xvi., 818) finds that on electrolyzing an ammoniacal solution of copper, the metal is deposited without contamination on account of the possible presence of Ag, Bi, Sb, As or Sn. Hg and Cd, however, may interfere under these conditions. If the action of the current is much prolonged after complete deposition of Cu—Ni, Co or Sn, if present, will also be partially deposited.

Electrolytic Separation of Palladium and Platinum from Iridium. Smith (*Am. Chem. Jour.*, xiv., 435) finds that iridium is not precipitated by the electric current from solutions containing an excess of alkaline phosphate and free phosphoric acid, whereas both palladium and platinum separate readily.

Detecting Chlorine and Bromine in Presence of Iodine. MacNair (*Chem. News*, lxvi., 5). Precipitate with excess of $AgNO_3$, filter and wash, and heat the precipitate with powdered $K_2Cr_2O_7$ and a little conc H_2SO_4. I is converted to $AgIO_3$ while Cl or Br if present, are evolved in elemental form.

Separation of Iodine and Chlorine. Jannasch and Aschoff (*Zts. Anorgan. Chem.*, 1892, 248), find that TlI is insoluble in dilute alcohol in presence of NH_4 salts, whereas TlCl is soluble.

To 40 or 50 c.c. of a solution containing about 0.5 gm. of the mixed alkaline salts is added 50 c.c. of a 20 per cent. $(NH_4)_2SO_4$ solution, and 30 c.c. of alcohol. A 4 per cent. solution of Tl_2SO_4 is then added, until precipitation is complete. After 12 hours standing the precipitate

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may be filtered off, washed with a weakly alcoholic solution of $(NH_4)_2SO_4$, finally with alcohol alone, dried and weighed.

Carbon in Organic Substances. Okada (*Arch. Hyg.*, xiv., 364). When organic substances are treated as in Kjeldahl process, all the carbon is evolved as CO_2. By passing the gases evolved through water (to take up SO_3, etc.) and then through permanganate (to remove SO_2) the CO_2 may be passed into $Ba(OH)_2$ and then estimated.

Determining Sulphide Sulphur. Marchlewski (*Fres. Zts. Anal. Chem.*, xxxii., 1) has made examination of these methods. The material used for the experiments was a slag cement containing 1.257 per cent. sulphur as sulphide and a small amount of sulphate. Tests were first made on methods involving direct oxidation of the substance, and subsequently precipitating $BaSO_4$.

Oxidation by *aqua regia* was taken as the control method.

Oxidation by *Cl* in *acid solution* or by use of *HCl and* $KClO_3$ gave correct results but was longer than the aqua regia method.

Oxidation by *Cl in alkaline* solution gave low results.

Fresenius's method of oxidation with *red fuming nitric acid* was more tedious than the aqua regia method on account of the difficulty of completly oxidizing the last portion of S.

Incidentally, experiments were made as to the volatilization of Fe_2Cl_6 on evaporating the HCl solutions. Loss of Fe_2Cl_6 was found to occur.

Oxidation *with Bromine* was not so generally applicable. A long time (24 hours) was necessary. Loss of Fe_2Br_6 on evaporation did not occur.

H_2O_2 *for oxidation* takes much time and is often incomplete.

Permanganate is unsatisfactory on account of the persistency with which Mn salt clings to the $BaSO_4$ involving long washing.

Fusion with *alkaline nitrate* gave correct results.

Baumann's endiometric method, depending on the following reactions was found unsuitable:

$$H_2O_2 + 2CrO_3 = H_2O + Cr_2O_7.$$
$$Cr_2O_7 + 3H_2SO_4 + 4H_2O_2 = Cr_2(SO_4)_3 + 7H_2O + O_8.$$

Volumetric methods, after conversion to alkaline sulphate, were tested. Those of Mohr, Clemm, Wilsing, Gawalowski, Böhlig and Knöfler. These methods depend upon the sensitiveness of alkalimetric indicators to alkaline carbonate, and their indifference to $BaCO_3$. Böhlig's method consists in causing an interchange of acids and bases between $BaCO_3$ and alkaline sulphate in presence of CO_2, the others in precipitation by standard $BaCl_2$, the excess of which reacts with Na_2CO_3 affording NaCl and $BaCO_3$, neutral to indicators. The results by these methods were usually within about 1 per cent., but the presence of ammonia salts (which could not well be avoided in many analyses) was detrimental.

Andrew's method.—Precipitation of sulphate by an *excess of* $BaCrO_4$ dissolved in HCl, and determining excess of chromate by adding KI and titrating the I set free, gave excellent results.

Various EVOLUTION METHODS were tried, the operations conducted in an atmosphere of CO_2.

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Craig's *H_2O_2 method* was very exact.

The *iodometric method*—essentially on the same lines as Elliott's (*vid.* Blair's *Anal. of Iron*, etc., 2d ed., p. 000)—of Fresenius, Bunsen, Topf, Gröger and Baumann, gave very exact and concordant results.

Muller's method, *passing the gas into HNO_3*, is elaborate and gives low results. *Aqua regia instead* of HNO_3 gave good results but no special advantage.

Permanganate as an oxidizer for the H_2S gave difficulty in the adherence of Mn salt to the $BaSO_4$.

Koninck's $AgNO_3$ method, consisting of filtering off Ag_2S, oxidizing with Br, filtering off the AgBr, and precipitating with $BaCl_2$ was slow but exact. Koninck's second method in which Hg was substituted for Ag was more convenient.

Weil's ammoniacal copper method in which the excess of Cu is determined in an aliquot part by titration with $SnCl_2$ proved untrustworthy.

Berg's *absorption by tin solution*, and titration by I after adding HCl gave good results.

Osmond's *colorimetric method with $AgNO_3$* and Hardy and Arnold's colorimetric method with $Pb(C_2H_3O_2)_2$ proved slow of execution.

The remark of Hibsch is quoted that iodine methods for S in evolution processes cannot be well applied to manufactured irons, since the hydrocarbons evolved affect the iodine.

Sulphur in Irons, Evolution Method. Schindler (*Zts. angew. Chem.*, 1893, 11), finds that unless conc. HCl (Sp. Gr. 1.19) is used in these methods (in an atmosphere of CO_2), all of the S will not be carried over in the evolved gases. This seems to explain the conflicting testimony of different chemists as to the value of these methods.

Sulphur in Sulphide Ore and in Some Organic Sulphur Compounds. Lindemann and Motten (*Bull. Acad Roy. Belg.* [3], xxiii., 827). To oxidize blende or pyrites, 0.2 to 0.3 gm. are rubbed up in an agate mortar with a few drops of concentrated bleaching powder solution to a thick paste. The rubbing is continued, with frequent addition of the bleaching powder solution, until a bulk of 30 to 40 c.c. is attained. Then HCl (of 5 per cent.) is added to small portions until the oxides are dissolved. Then stronger acid is added to dissolve the $CaSO_4$, the solution is gently warmed to expel Cl and after filtration the solution is precipitated with $BaCl_2$. With galena all the lead is converted by this treatment to PbO_2.

Sulphur in Burnt Pyrites. Lunge (*Zts. angew. Chem.*, 1892, 447), applies Watson's method thus: 3.2 gms. of the sample are mixed with 2 gms. $NaHCO_3$ of known alkalimetric strength, and the mixture is heated in a nickel crucible to a temperature sufficient to decompose the bicarbonate for 10 to 15 minutes. Then a stronger heat sufficient to render the mass red hot, but not to fuse it, is applied for 10–15 minutes more. The mass (which should be black and porous) is treated with hot water, and a strong solution of absolutely neutral and pure NaCl is added that a clear filtrate may be obtained. If it does not run clear, more NaCl must be added. The clear filtrate and washings are titrated with fifth

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normal HCl. The S is calculated from the amount of alkalinity of the bicarbonate which has been destroyed by conversion to Na_2SO_4.

Sodium Hyposulphite and Potassium Permanganate. Luckow (*Fres. Zts. Anal. Chem.*, xxxii., 53), finds that in acid or alkaline solutions the reaction between these salts affords sulphate and hyposulphate, which may be detected after precipitating sulphate by $BaCl_2$. The action might be represented thus:

$$2\ Na_2S_2O_3 + H_2O + O_7 = 2\ Na_2SO_4 + H_2S_2O_6.$$

Phosphorus in Iron Ores. Crobaugh (*Jour. Anal. and App. Chem.*, vi., 483). Treat 5 gms. in a 6-inch evaporating dish, with 60 c.c. conc. HCl. Rest the dish on a large disc of asbestos board which has a two-inch hole in the centre. Evaporate to 15 c.c. Add 35 c.c. HNO_3 and evaporate to 15 c.c. Dilute to about 35 c.c.; filter into a shaking flask. Ignite the filter over a blast lamp and fuse with Na_2CO_3. Dissolve the melt in about 25 c.c. of dilate HNO_3 (Gr. 1.135) boil and then filter into the shaking flask. The total bulk of the united solutions need not exceed 150 c.c. Heat to 90 c.c., add 75 c.c. molybdate solution (Drowns's formula). Shake 5 minutes as usual, filter, wash with 2 per cent. H_2SO_4. Reduce with granulated zinc. After reduction filter through a funnel stopped with a small plug of cotton to remove the Zn. Titrate. The operation may be carried through in 1½ hours.

Possible Error in Gravimetric Determinations of Phosphate. Neubauer (*Zts. f. anorg. Chem.*, 1892, 45) finds that in some cases P_2O_5 is volatilized by ignition of the Mg precipitate. The idea is expressed that in the presence of free ammonia some mono-magnesium phosphate $Mg(NH_4)_2(PO_4)_2$ is precipitated. On ignition metaphosphate is formed, which, by continued heating, passes into pyrophosphate with loss of P_2O_5.

Phosphoric Acid in Basic Slags. Jolles (*Zts. Anal. Chem.*, xxxl., 516) finds that the method of Albert, according to which the slag is treated with HCl, and evaporated only to a jelly, gives inaccurate results, the Mg precipitate always containing SiO_2. He recommends evaporating to complete dryness, filtering, etc., adding Joulie's solution (ammoniacal ammonium citrate) and precipitating with magnesia mixture. The volumetric method with uranium salt he finds untrustworthy, and quotes with approval the decision of the Congress of Chemists at Hanover to the same effect. Firby (*Chem. News*, lxvi., 293) criticizes adversely the method here given, as he finds that the use of Joulie's solution gives results too high.

Titration of Pyro- and Meta- Phosphates. Von Knorre (*Zts. Ang. Chem.*, 1892, 639) finds that methyl orange is neutral to $Na_2H_2P_2O_7$. Phenolphthalein shows the alkaline color with $Na_4P_2O_7$, but acid with $Na_2H_2P_2O_7$. With $Ca_2P_2O_7$, however, it is neutral, so that by adding $CaCl_2$ and titrating with $Ca(OH)_2$ solution neutrality is attained with phenolphthalein as indicator, when the solution contains $Ca_2P_2O_7$.

Attempts looking to the determination of metaphosphate in presence of pyrophosphate were unsuccessful.

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Kjeldahl Process. Gunning's Modification. Winton (*Bull. No. 112, Conn. Agr. Exp. Sta.*) finds that the chief objection to Gunning's method lies in the frothing of the mixture (18 gms. K_2SO_4 with 20 c.c. H_2SO_4) during the first stages of the operation. (With this proportion of K_2SO_4 the use of Hg or HgO is unnecessary). In the case of substances containing nitrates, the reduction of the nitrates with H_2SO_4, salicylic acid and zinc (Scovell's method) must be performed before any K_2SO_4 (12 gms.) is added, otherwise the heat which must be applied to keep the mass liquid is too high. When the organic matter has been destroyed, water is added gradually to maintain the solution. The distillation with NaOH is finally conducted in the usual manner.

Arnold and Wedemeyer (*Zts. Anal. Chem.*, xxxi., 525) find that the destruction of the organic substance proceeds more rapidly if the Gunning method is combined with the use of HgO and $CuSO_4$, as recommended by Arnold. (*Zts. Anal. Chem.*, xxv., 581). The K_2SO_4 was added a little at a time to moderate the frothing. In the distillation, if Zn dust is added, the use of K_2S is unnecessary.

Total Nitrogen (*Kjeldahl Process*). Huguet (*Jour. Pharm. Chem.*, [5], xxvi., 54) proposes to heat to boiling a mixture of 10 gms. $KHSO_4$ and 5 c.c. conc. H_2SO_4, and then to add the material (little by little); if a liquid, drop by drop, the blackening of the acid being allowed to pass off more or less completely after each addition. The rest of the method is conducted as in the case of the Gunning modification. Substances which yield with difficulty to the process as ordinarily conducted, are more readily managed by this modification.

Nitrous and Nitric Acids. Veley (*Chem. News*, lxvi., 175), in making experiments as to the conditions of formation and decomposition of HNO_2, finds that the oxidation of HNO_2 by permanganate is very slow toward the end of the operation, so that to get a satisfactory determination, a slight excess of permanganate is added, the solution allowed to stand 30 minutes, and the excess of permanganate determined by KI and standard $Na_2S_2O_3$. By determining the total acidity in another portion, the data for estimation of both HNO_2 and HNO_3 were obtained.

Color Standard for Waters. Hazen (*Am. Chem. Jour.*, xiv., 300) proposes to make a standard solution containing 1.246 gms. K_2PtCl_6 (= 0.5 gm. Pb), 1 gm. crystallized $CoCl_2$ (= 0.25 gm. Cu), and 100 c.c. conc. HCl per litre. 1, 2, 3, etc., c.c. of this stock solution are diluted to 50 c.c. in Nessler cylinders, corresponding to 0.1, 0.2, 0.3, etc., degrees of color standard.

METALLURGY, BY JOSEPH STRUTHERS.

COPPER. BESSEMERIZING COPPER MATTE.—"The Treatment of Copper Ores at Bogolowsk, Russia," *Annales des Mines*, 9th Series, vol. ii.

The ore treated is a cupriferous pyrite occurring in diorite veins carrying 4 to 5 per cent. copper. Analyses made in 1889 showed:

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	Bachmakof.	Rachette.	Troitzky.	Pestchank.
S.....	10 04	1.58	0.339	4.52
SiO_2.....	14.93	37.05	45.70	32.70
Fe_2O_3	55.42	19.61	18.85	26 42
Al_2O_3.....	1.84	2.39	3.44	4.53
MnO	0.50	0.55	0.46	0.852
CaO.....	5.68	11.75	10.75	26 17
MgO.....	Traces.	Traces.	.....	.....
CuO	5.62	3.88	3.44	1.59
	(Cu 4.48)	(Cu 3.10)	.....	(Cu = 1.27)

The Bessemer Process.—The application of the Bessemer process to copper mattes presents great difficulties; when the production of black copper from matte is attempted in one operation, the temperature of the metallic bath falls very low towards the end. At the beginning, owing to the oxidation of the iron and sulphur, the temperature is high. At the end, however, black copper is scattered through the matte, and sponges are formed which thicken the bath and are cast out violently by the blast. In this way large losses of copper occur. At the end the copper obtained is spongy, poor, and refined with difficulty. M. Auerbach divided the operation into two parts, the first oxidation giving a white metal of 60 per cent. copper, the second, black copper of 96 per cent., with the advantage of separating the poor slags of the first operation from the rich slags of the second operation. This division causes less loss in copper and but slightly increased expense, owing to the fusion of the matte in a reverberatory furnace. In a converter of the Manhès type the tuyeres are in a horizontal position, almost at the surface of the bath. Shortly after the commencement of the operation slags are abundantly formed at the surface. The blast then acts on these slags and not on the matte and the oxidation is considerably less energetic. If these tuyeres are placed vertically at the bottom as in the Bessemer converter for steel, the black copper remains at the bottom owing to the difference in gravities between it and the matte. The blast then blows through the copper, giving rise to projections and losses. M. Auerbach places the tuyeres at an an angle of 45°, and so calculates the quantity of the charge so that when the white metal or black copper is formed the surface of the separation from the slag is almost at the outlet of the tuyeres. In this manner he does not blow through the slags, nor does he oxidize the product, rich in copper, which remains at the bottom. One of the causes which led to the abandonment of the Manhès process at the Vivian works was the enormous consumption of refractory materials. The melted white matte is extremely corrosive. In a very short time it cuts through the hearths of the reverberatories and strongly corrodes the sides of the converters; as in the Bessemer process for steel, it is impossible to charge siliceous sand without freezing the bath, the scorification is therefore made at the expense of the

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lining. When the use of high quality refractory material is made, after a few blows the lining must be replaced. M. Auerbach uses ordinary clay, which answers sufficiently well for both converters and reverberatories. This common clay is hardly attacked any more than siliceous bricks, and is replaced with slight expense. Under these conditions the modified Manhès process is successful. In August, 1891, the Bessemer works, built at a cost of 200,000 roubles, consisted of eight converters in two groups, with two reverberatory furnaces for each group. In a group of four converters, one is in operation, one is being repaired, one is cold, and the fourth is being reheated.

First Operation.—The iron mattes which serve as a starting point for the operation are obtained by a fusion of the copper ores in the furnaces of the old plant. These mattes contain about 20 per cent. copper. They are shovelled into the reverberatory furnaces; each charge is 1.6 tons and the time of fusion about 3 hours. The fuel consumption is about 1 cubic metre of wood per ton of matte. When the matte is melted the converter is turned down horizontally, and the matte is run from the furnace to the mouth of the converter through a movable trough lined with a mixture of charcoal and quartz. When the reverberatory is empty the converter is turned up and and the blast commenced.

The first operation eliminates iron and produces a rich white metal, occupying about 25 minutes. The combustion of the iron and sulphur rapidly raises the temperature of the blow. The flame which laps the mouth of the converter is yellow, violet edged, and is crossed by brilliant sparks. When the flame diminishes and becomes green it is a sign that the iron is burnt, and when it becomes entirely green the operation is ended and the matte is run into moulds. After cooling the slag is separated from the matte by the blow of a hammer. The white metal averages 64 per cent. copper.

Second Operation.—The white metal is remelted in a reverberatory furnace and is then treated as in the first operation. The second blow is more difficult than the first. The temperature is low owing to a scarcity of sulphur and this, which is the chief impurity to be eliminated, is not disengaged at a low temperature. At the moment the metal threatens to congeal when the projections appear, charcoal is thrown into the converter to raise the temperature. Two workmen remain constantly by the converter clearing the tuyere holes with iron rods. The time of the blow is from 1½ to 2 hours. It is considered finished when on introducing a shovel in the converter the projections which solidify upon it as they descend are no longer of white metal. The flame which was green at the beginning is now yellowish red. The slag containing 5 to 6 per cent. copper flows out first when the converter is turned and then the black copper. The refining of this black copper is accomplished by the ordinary reverberatory process. In the same converter there are three or four operations for white metal, then two for black copper, then two or three again for white metal, in order to dissolve the masses of copper which remain in the converter.

Details as to cost of mining and various methods of producing matte and black copper in shaft furnace, spleissofen and converter are also given. An illustrated plate, showing details of converter, accompanies this article.

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Analyses of the Different Products.

	White Metal.			Black Copper.		
	No. 1. Poor Blow.	No. 2. Good Blow.	No. 3. Poor Blow.	From Converter.	From Speiss Furnace.	From Copper Furnace.
Cu	75.08	68.6	76.76	95	97.72	92.72
Fe	3.52	7.5	2.06	.....	0.04	5.28
Ni and Co	0.82	0.51	0.76	.....	0.35	1.42
Ag	Traces.	Trace.	Trace.	.....	Trace.	Trace.
As and Sb	0.08	0.06	0.04	.....	0.17	0.65
Sn	0.07	.....	.....	.....	.....	.....
S	20.34	23.22	19.46	.....	0.01	Trace.
O	.....	.....	.....	.....	1.81	0.69

Slags Obtained from White Metal.

	No. 1.	No. 2.	No. 3.
SiO_2	27.28	33.70	30.54
Al_2O_3	3.74	1.62	3.84
Cu	1.62	0.84	1.74
Fe	49.98	47.59	47.18
Co and Ni	0.78	0.76	1.10
As and Sb	Traces.	.....	.....
Sn	0.21	.....	.....
CaO	0.12	0.95	0.50
MgO	0.11	0.38	0.11
S	0.82	5.93	0.76
O, etc	15.34	8.23	14.23

Refining of Gold and Silver.—(*State School of Mines Scientific Quarterly*, Golden, Colorado, December, 1892.) "The Fire Refining of Gold and Silver," by R. P. Andrews.

Melting and refining of gold and silver are not necessarily connected with the assayer's profession, yet he should have a knowledge of this branch of skilled labor.

Bullion received by mints for subsequent coinage consists of mill retorts, placer gold, bars and old jewelry. The retorts generally con-

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tain iron, either from the stamps or from the pyritous ores, as sulphides, with lead, antimony and arsenic. Placer gold is often mixed with black sand and lead; the lead may occur naturally with the gold, but much of it finds its way to the sluices from the hillsides, which are continually peppered by gunners in the hunt for small game. The bars are debased by lead, arsenic and antimony, which have not previously been removed by any refining process.

Fire refining is carried on in fire-clay or sand crucibles, which are placed in plumbago melting pots to catch the metal in case the crucible cracks or breaks. When the melt contains iron, as in the case of mill retorts, the surface becomes covered with a thick coating of fused iron sulphide, which can be removed by the tedious method of oxidizing with nitrates of soda and potash. Much time will be gained by pouring the fused metal into a mould, and, after cooling, separating the slag from the bar. The slag so obtained should be melted with iron scrap to recover any gold enclosed within it. The gold is remelted, with the addition of any gold recovered from the slag, and when molten, nitre is thrown on the surface with occasional additions of borax glass to thicken the flux. The flux is removed by means of a stirrer of plumbago kept always at the furnace temperature. After the iron has been removed from the slag there will probably remain lead and antimony to be separated. This is done by continued additions of nitre. But little effect is shown at first when these metals are in excess. The color of the extracted flux is the indication by which the refining is guided. Commencing with a whitish yellow, the color passes to light green and then to darker green as the work nears completion. Finally, before the entire removal of the lead, rainbow colors will rapidly flow over the metal as in cupellation. The gold is apt to bubble slightly, but as the last traces of lead disappear becomes perfectly quiet, of a rich color, with smooth and clear surface. It is now ready for casting.

Should the lead and antimony stubbornly resist the oxidizing effect of nitre, a small piece of bichloride of mercury or sal ammoniac may be added. The chloride penetrates the whole mass of the metal and forms volatile chlorides, which rapidly rise to the surface and are volatilized. This action is different than that of nitre, as the latter remains on the top surface of the metal and oxidizes the lead and antimony as they rise. Bichloride of mercury is more efficient than sal ammoniac, but requires greater care in handling it, on account of its poisonous qualities.

Some refiners add oxide of copper to aid in the extraction of the lead.

When arsenic is present in the gold the same plan is followed as with lead; it requires closer attention and more patience to eliminate it.

Silver is refined in the same way as gold, but extreme care must be taken to keep the temperature of the furnace as low as possible to prevent the volatilization of the silver. It is not advisable to use either bichloride of mercury or sal ammoniac in refining silver.

In an establishment having a large wind-melting furnace connected to the flue by a wide throat, cupellation may be economically and advantageously performed. This method is almost a necessity in the case of very base bullion. The bottom of a plumbago melting-pot well tamped with bone-ash and hollowed out to receive the metals will make

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an excellent cupel. The cupellation requires no other attention than to keep the heat at such a stage that the cupel will not freeze, and so the process can be carried on at the same time the furnace is running on other work. If the metal becomes solid before the oxidized metals are all absorbed by the cupel the completion of the refining is carried out in a crucible.

Nitrate of potash is generally used in refining, though it contains 10 per cent. less nitric acid than the corresponding nitrate of soda. However, the latter is generally impure and contains common salt which, in the refining process causes the gold to spurt with consequent serious loss.

If the operator has only a plumbago melting-pot for refining purposes, the corroding effect of the nitre on the plumbago can be prevented by making a ring of bone-ash which will gradually absorb oxide and become well fixed to the inside of the pot. This ring protects the plumbago by keeping the nitre in the central part of the surface of the melt.

CALORIMETRY.—(*Stevens's Indicator* for Nov., 1892). "Calculation of the Heat of Combustion of an Illuminating Oil-gas, and Comparison with the Heat determined by Experiment," by Prof. D. S. Jacobus.

This paper gives, in general, the method of ascertaining experimentally the heating value for the gas in question. The illuminants in the hydrocarbon gases, with the exception of marsh gas, cannot be separated from each other without a very elaborate analysis, so an assumption is made of two probable values; within these limits the value of the gas lies. The experiments showed a value of only 1.1 per cent. below that calculated theoretically. The apparatus for ascertaining the amount of heat given off consists of an air-tight box having inlet and exit pipes, the top pipes being furnished with lamps, the lower pipe with an anemometer; the lamps are run at the required candle-power, and the readings of the various thermometers so arranged to get the average temperature of air in the box, and protected from radiant heat either direct or reflected, are carefully made, also that of the anemometer in the inlet pipe. After running steadily for about three hours the lamp is taken out and a steam radiator coil put in its place. By regulating the amount of steam which flows into the radiator the temperatures and reading of the anemometer are made the same as for the lamp. The amount of heat given up by the radiator coil is then the same as that given up by the lamps, and may be determined from the value of the steam condensed.

BLAST HEATING.—Advance sheets *Trans. Amer. Inst. Min. Engrs.*, Oct., 1892. "The Hugh Kennedy Hot-Blast Stove," by W. C. Coffin.

Fire-brick stoves have become a necessary part of the modern coke blast-furnace equipment, and are also superseding the cast-iron pipe-stoves in anthracite- and charcoal furnaces.

The brick stoves in general use are of either the Cowper or Whitwell type, or modifications of these bearing the names of those who invented the alterations from the original types rather than any real departure from them. All these stoves have approximately the same valve-equipment and follow the same line of operation. The waste gas from the furnace enters at one port and burns in a single combustion-chamber, and the heated products are drawn through the various passes in the

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brickwork to a stack of proper height to create the necessary draught. The last passes of these stoves receive a very small percentage of the heat from the gas, owing to their extreme distance from the combustion-chamber; and this chamber also suffers great deterioration in the attempt to force the heat into the farthest passes. At best, about 70 per cent. of the heat taken up is held in the combustion-chamber and the first down-pass of the Whitwell stoves.

Mr. Hugh Kennedy, impressed with the fact that but about 30 per cent. of the brick of the average stove were doing proper duty as heat agents, had three 20 by 60 feet stoves constructed with a view of more uniformly heating all the brick. In these the general lines of the Whitwell stove are followed, with the blast-connections unaltered, but gas is introduced at the bottom of each pass, and outlets are provided at the top, so that the gases have a direct natural draught in each pass and the highest heats are obtained at the bottom instead of the top. The natural tendency being toward the reverse condition, the brickwork soon acquires an almost uniform temperature.

The blast in the Hugh Kennedy stove passes after entering from the cold-blast uptake, down through the checker-work into the combustion-chamber of one section of the stove, then into the combustion-chamber and up through the checker-work of the second section, and down through the checker-work to a combustion-chamber of a third section, then out through the hot-blast valve, thus making a single pass for gas and allowing four passes for the air.

The Spearman burners are used exclusively on these stoves, and give a perfect combustion in the small lower chambers. This stove can be kept free from dust and slag, these being precipitated on the floor by the sudden expansion of the gas in the low chambers.

PYROMETRY.—*Transactions of the American Institute of Mining Engineers*, June, 1892. "The Wiborgh Luft (Air) Pyrometer," by Emanuel Trotz, Worcester, Mass.

The theory of the instrument is based on the co-efficient of expansion of air. The volume of the vessel being made practically constant, the expansive force is converted into pressure which is registered by a manometer and from this the temperature is calculated, the pressure being thus directly a function of the temperature, due correctness for barometric pressure-expansion, etc., being considered.

Description of the Instrument.—The outer covering of the instrument consists of a round metal box with a firm bottom, to which the pyrometer-pipe, composed of a globe and a capillary tube, is screwed. In the box, close to the bottom, a lenticular metal vessel is fastened of such form and elasticity that it can be completely compressed and will afterwards resume its former shape. On the opposite side of this vessel is fastened a metal plate with a cylindrical projection, which is likewise provided with a capillary tube. Moreover, as the lenticular vessel has on both sides, opposite the two capillary tubes corresponding openings, the two air-volumes used are connected with each other and with the outside air.

To the bottom is screwed an iron bow, forming a support for an axle, which aids in compressing the vessel. For this purpose the said axle is provided with a short lever, operating a small rod, which latter, at the turning of the axle, descends, and, first closing the capillary opening,

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then presses down the projection, together with the plate, whereby the lenticular vessel can be compressed that all the air formerly contained in it will be forced into the globe.

For measuring the consequent rise of pressure the capillary tube is connected by a fine leaden pipe with a manometer spring, which in the usual way, by means of gearing, communicates to the hand the motion produced by the increased pressure in the spring. The leaden pipe must, of course, be bent and sufficiently long, so that its inner end can follow along with the projection when the vessel is compressed.

In addition to the temperature scale on the dial plate, there is a small scale for correcting barometric pressure, also a small thermometer for ascertaining the temperature of the atmospheric air used in the test and as a small aneroid barometer.

Now, if the instrument be properly adjusted with reference to these scales, all that is necessary at an observation is simply to find on the scale of the movable metal ring the figure corresponding to the temperature given by the thermometer, and turn the ring until this figure coincides with the figure in the small scale farthest down on the dial plate, representing the pressure as shown by barometer.

The hand which receives its motion through increased pressure in the manometer-spring, indicates the temperature on the large scale (graduated from 0° to 2400°) of the dial plate.

To lessen the fragility of the porcelain pipe used as a part of the pyrometer, and to get it to stand immediate contact with very high temperatures without breaking, it is wound with asbestos wicking. The graduation of the instrument is made in accordance with the theory given above, and with an appropriate correction for capillary relations, determined by a new and theoretically accurate principle.

Claims are made for practical accuracy up to 2400° F.

BLAST-FURNACE PRACTICE.—Advance sheets of the *Transactions of the American Institute of Mining Engineers*, October, 1892.)—David Baker gives an illustrated article on "The Application of the Rock Drill for Opening the Tap-Hole of Blast-Furnaces."

In speaking of labor-saving devices in immediate connection with the operation in the blast-furnace, but little has been done apart from hoisting and blowing. The charging, tapping, casting and handling of the pig-iron in the beds are still performed chiefly by manual labor. At almost all furnaces filling is done with the hand-barrow of twenty-five years ago, and it is only recently that here and there chills have been employed in the cast-house, instead of the usual sand-beds, to lessen the labor of handling the pig as well as to secure its greater purity.

The manual labor of opening and closing the tapping-hole has been rather increased than diminished by the enlarged hearths, and greater capacity of the modern furnaces renders it more difficult to keep the tap-hole back. In the old-fashioned smaller furnaces the slacking of the blast-pressure, and the introduction of a single bed of clay, involving an average stoppage of not more than three minutes, sufficed for plugging the hole, and opening it was comparatively easy. Ordinary brick clay was found sufficiently refractory. At present fire-clay mixed with graphite is sometimes used, or material of old black-lead crucibles is rammed in with balls of clay, and, instead of one ball, a wheelbarrow

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load is often required. To make a large hearth safe against "break-outs" the clay stopping should be "kept back" three feet from the outside of the tap-hole. To open at casting time one of these deeply and thoroughly stopped iron notches requires the labor of eight to ten men drilling with a heavy bar from ten to thirty minutes, according to the condition of the furnace, and the work is very exhausting. At the Maryland Steel Company's furnaces the system of employing a percussion rock drill as tap-hole opener has done away with the hard work of so many men. The drill employed was the Little Giant No. 4 of the Rand Drill Co., mounted on a regular swivel base, clamped to a horizontal bar, which was swung from a column as a crane. Difficulties were at first encountered by having too short a feed and too long a time for the removal of the bit after the hole had been drilled. These were finally adjusted, and the present work is satisfactory. The advantages of the power drill over the old hand drill are:

1. Quicker and cuts a better hole; that is, more near a true circle. It is found that this tends to make the tapping-hole stand longer against cutting out by the hot iron and cinders.

2. The percussion drill itself is useful for other furnace purposes, such as drilling salamanders, etc.

3. The important saving in labor before the furnace.

PIG-IRON. PRODUCTION IN 1892.—*American Manufacturer*, January 27, 1892, quotes from report of the American Iron and Steel Association as follows:

"Total production of pig-iron in 1892 was 9,157,000 gross tons, against 8,279,870 tons in 1891 and 9,202,703 tons in 1890.

"The production of spiegeleisen and ferro-manganese in 1892 was the largest yet recorded, reaching 179,131 gross tons, against 127,766 tons in 1891 and 133,180 tons in 1890."

Production in 1892, According to the Fuel Used.

	Blast Furnaces, Dec. 31, 1892.			Production, Including Spiegeleisen.
	In Blast.	Out of Blast.	Total.	Gross Tons.
Anthracite...	72	87	159	1,797,113
Charcoal	43	94	134	537,621
Bituminous ..	141	130	271	6,822,266
Total.....	256	311	564	9,157,000

IRON ALLOYS. OBSERVATIONS ON FERRO-TUNGSTEN.—(*Journal Franklin Institute*, Dec., 1892).

Wm. H. Wahl, in the course of an investigation on ferro alloys, arrived at the conclusion that the saturation point of iron for tungsten is represented by the ratio exhibited in the compound Fe_4W, and that any excess of tungsten above this ratio present in a tungsten iron, will remain uncombined.

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BOOK REVIEWS.

THE MINING LAWS OF THE REPUBLIC OF COLOMBIA, with a short explanation of their application, and official forms for notices, denouncements and applications for title. Translated and edited by Charles Bullman, M.E. New York: The Scientific Publishing Company. 1892. Pp. 107. Price, $1.50.

In this work a task has been performed which cannot fail to meet with appreciation, not only amongst those in this country who are interested in mining in Colombia but also in Colombia itself.

Since the passage of the last mining code of the State of Antioquia, in 1867—a code which was afterward adopted by the Colombian National Government—a large number of new laws and amendments have been formed.

As stated by the translator in his introduction, these additional enactments have been published from time to time in the official gazette at Bogotá and in the various government publications, but hitherto no attempt has been made to classify and incorporate them with the original code.

As a result, some confusion in the understanding and application of the law has been inevitable, especially in taking up new claims in the older mining districts. In order to conform with the later provisions of the law, persons desiring to locate new claims found it necessary to consult files of the official papers—often obtained with difficulty in remote districts of a country like Colombia, where communication is often slow and uncertain. The writer of this notice has seen in Colombia a scrap-book made up of newspaper clippings containing the successive additions and amendments, and used as an appendix to the code.

The Colombians are desirous of attracting foreigners to their country, and the mining laws are liberal, and, as a rule, well framed. The code is based upon the old Spanish mining laws, which were in force more than 300 years ago.

Originally, the boundary lines of a claim were calculated, as usual, to the horizontal, independently of the surface configuration; it will be noted, as a peculiarity of the newer law (Art. xxv., p. 11) that "measurements of the claim or claims shall be made on the surface, and not on a horizontal plane." As a matter of fact, this was done because of the numerous blunders made by the deputy officials charged with laying out the claims. A hand compass and chain are now the only instruments required in fixing the boundaries of a claim, though this rough survey may be followed, of course, by a more accurate one.

The general instructions for the taking up of mineral property (pages 87–95) are specially valuable to foreign miners in Colombia and to engineers and others intending to embark in mining enterprises. The book is an octavo of 107 pages, is well printed, and deserves hearty commendation as being not only the first translation but also the first orderly collection of the Colombian mining laws. R. P., JR.

THE METALLURGY OF LEAD AND THE DESILVERIZATION OF BASE BULLION. By H. O. Hofman, E.M., Ph D. 8vo., 414 pp. Cloth, $6.00. The Scientific Publishing Co., 27 Park Place, New York. 1892.

The work is divided into three parts, the first reviewing the history of

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lead with statistics of its production; the properties of lead and its compounds of metallurgical importance closing with the methods used in sampling, assaying and purchasing of ores.

The second part is devoted to the metallurgical treatment of lead ores and comprises nearly one-half the entire work. The methods are described under the three heads:—Reverberating, ore-hearth and shaft furnace treatment. The treatment in the shaft furnace is given great prominence, occupying 162 of the 217 pages of this second part.

The third part embraces the desilverization of base bullion, and is discussed under the heads of Pattinson's; Luce Rosan's; Parke's zinc desilverization, and English and German cupellation. The main stress is laid on Parke's process of zinc desilverization and the process of English cupellation with its American modifications. The other processes are described more briefly.

In the arrangement of this work the author has kept in mind three classes of readers,—the student, for whose use the ground principles and many definitions are given a prominent place; the metallurgist, who needs minute details for his practical operations; and the investigator, who will find in the foot-notes the principle references for the subject in its various branches.

The work is commendable if for no other reason than the collection and arrangement of the numerous papers on American metallurgy which have appeared from time to time in the publications of the various scientific societies and in the scientific papers. This arrangement is supplemented to a great extent by direct comparisons with foreign practice, and as such will prove of value to those interested in the subject. The abundant foot-note references greatly enhance its worth. It is to be regretted that drawings of such modern practice as tank water-cooled reverberatory furnaces for lead softening and Bessemer converters for refining base bullion are omitted from the work.

It is well illustrated by 275 cuts, and the typography and quality of illustrations are good. The concise index at the end of the book renders the contents easy of access.

Detailed Description of Contents:—Part I. Introductory.—Chapter I.—Historical and statistical notice. Chapter II.—Properties of lead, and some of its compounds. Chapter III.—Lead ores. Chapter IV.—Distribution of lead ore. Chapter V.—Receiving, sampling, assaying and purchasing of ores, fluxes and fuels.

Part II.—Metallurgical treatment of lead ores.—Chapter VI.—Smelting in the reverberatory furnace. Chapter VII.—Smelting in the ore-hearth. Chapter VIII.—Smelting in the blast-furnace.

Part III.—Desilverization of base bullion. Chapter IX.—Pattinson's process. Chapter X.—Parke's process. Chapter XI.—Cupellation process. J. S.

ELEMENTS OF GRAPHIC STATICS. By L. M. Hoskins, of Leland Stanford University. MacMillan & Co. 191 pages, 5 two-page plates at end of book. $2.25.

Part I.—General Theory.—Chapter I.—Concurrent Forces. Chapter II.—Non-concurrent Forces. Chapter III.—Internal Forces and Stresses.

Part II.—Stresses in Simple Structures.—Chapter IV.—Introductory. Chapter V.—Roof Trusses; Framed Structures Sustaining Stationary

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Loads. Chapter VI.—Simple Beams. Chapter VII.—Trusses Sustaining Moving Loads.

Part III.—Centroids and Moments of Inertia. Chapter VIII.—Centroids. Chapter IX.—Moments of Inertia. Chapter X.—Curves of Inertia.

A glance over the above list of chapters will give to one familiar with the subject an idea of the line of treatment, but, perhaps, only one experienced in teaching statics will realize a feature distinguishing this book from the great majority of those written on the subject of graphic statics. The author has not aimed to give a mere process for determining stresses. His endeavor has been to give the student a broad grasp of the graphic process as a branch of mathematical science, and make him look upon the calculation of stresses merely as one of its applications.

In this particular, simple in its statement, but meaning much in its ramification, most books on statics are at fault, because they do not clearly present this view.

Another feature which the writer has never seen presented in a textbook as distinctly as in the one considered, is the distinction between external forces and internal stresses, the one the cause, the other the effect; the one set being known, the other set to be determined. Elementary as this may be, yet it will be found that the novice often works aimlessly from lack of appreciation of it.

In Part I. the polygon of forces is elaborated directly from the parallelogram of forces, and for the proof of the latter the inquirer is discreetly referred to his mechanics. The equilibrium, or funicular polygon, is presented and used in connection with non-concurrent forces, and that all-important principle in graphic statics by means of which moments are graphically determined is set forth.

This is so vital to a broad application of graphic statics that its deduction was little less than a great discovery, and it should not be forgotten that the scientific world is indebted for it to Professor Culmann.

Chapter III. of Part I., is devoted to "Internal Forces and Stresses," a title covering the relation of internal stresses to external forces, and the conditions assumed in the application of graphic statics to framed structures.

The opinion of it can be summarized in these words: Well-presented, elementary, and for that reason, perhaps, often omitted by writers, but most important to the student if he is to have a clear idea of the significance of the subject studied.

The treatment of stationary loads on roofs, is, in connection with the plates at the end of the book, quite satisfactory. All the essential types of truss are given, although some hypercritical person may find exceptions.

In discussing the failing cases of the method Professor Hoskins resorts to the equilibrium polygon. It would have been well to also give short methods of meeting the difficulty, based upon analysis of the distribution of stress throughout a frame.

There is one feature in which, if the writer is not mistaken, the present book and all others are inadequate in their treatment of roof trusses. Careful attention is given to wind stresses in the roof, and no thought whatever to the building on which it rests. Many a roof has been care-

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fully designed for a wind pressure that would, if once exerted, speedily make a scrap heap of the building itself. In many structures the roof is a most important feature for the stability of the whole, and in treating wind stresses it cannot be entirely separated from the lower part of the structure.

Beams and plate girders are discussed in Chapter VI., and, of course, shear and bending moment. The usual diagrams are given, and toward the close of the chapter the important analytical discussion of position of distributed load for maximum shear and bending moment in a section.

Chapter VII. gives what is usually stated under the heading of bridge trusses. The relation of stresses and the moving loads causing them is fully stated, and the graphical processes for ascertaining the stresses both for uniform rolling loads, and for concentrated engine loads, such as stated in modern bridge specifications. In the latter case the treatment is to use the analytical process to determine the proper engine advance for maximum stress, and then find the corresponding shear and bending moment by the graphical method.

Part III. is a distinct portion of the book. The word centroid need not alarm the student, for it is merely a more general term for centre of gravity.

The determining of the latter is the chief purpose of the first part of this section. The remainder of the book, some thirty pages, is devoted to graphical representations of moment of inertia and its determination. All of which is useful but not so necessary to the student as the preceding pages. J. L. G.

RETAINING-WALLS AND MASONRY DAMS. By Mansfield Merriman. John Wiley & Son. 122 pages.

Professor Merriman is noted for his skill in presenting a clear, concise statement of the principles of a mathematical subject. This, his latest work, is on a subject which can be approached from an ultra mathematical standpoint, or from one entirely experimental and practical. The intricacy of the conditions involved in design of retaining walls leads some engineers to depend entirely upon a formula, and others to discard theoretical treatment absolutely and use some simple rule of experience.

There is no general agreement upon a well-defined process of design, nor indeed, can there be, until science enables us to analyze with great minuteness the interplay of cohesion and friction with all the modifying effects of vibration, moisture, temperature, frost, etc., upon earth, sand and other materials in mass.*

Under these circumstances it is not to be expected that Professor Merriman, or any other writer, will differ materially from predecessors in their methods of treatment of the subjects.

With the exception possibly of the first chapter, which treats of slopes of excavation and embankment as affected by cohesion as well as friction, a topic not so generally discussed in writings on engineering, the strong-

* It will be interesting in this connection to read a short article by Professor Merriman in the QUARTERLY, Vol. IX., p. 109.

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est claim of the book is its systematic, concrete arrangement of many most important facts; an arrangement which makes it of value to practitioner and student alike. The former, however, would probably like to find more reference to actual failures and successes, such as were given several years ago by Mr. Baker, of Forth bridge fame, in his valuable paper on retaining-wall practice.

In Chapter II. is discussed the point of great significance in retaining-wall discussion; that which gives to it its peculiarly uncertain nature. What shall be taken for the angle of inclination, the amount, and the point of application of the lateral pressure against the walls? Professor Merriman inclines to considering the pressure normal to the wall, but he treats with respect the theory which Rankine develops by the discussion of conjugate pressures and their laws, to the effect that the pressure is parallel to the upper surface of the earth.

All tastes are suited, however, by the presentment of an analytical discussion leading up to a general formula in which, by inserting a proper angle, one can select an inclination of the lateral pressure to please himself. It may be suggested in this connection that neither these nor any other formulas take account, as indeed they can not be expected to, of what seems to be an entirely reasonable question. Can it be positively denied that the lateral pressure changes its inclination at different depths, even in a homogeneous earth, owing to resultant effects of superimposed weight, cohesion, compressibility, etc.?

Having determined on the lateral pressure, one finds in Chapter III. a discussion of the laws of stability, under the well-established heads, rotation, sliding, and maximum compression on the masonry. The first two are treated both graphically and by equations, and in the latter the "middle third" receives its deserved attention.

Chapter IV., in twenty-five pages, gives the process of designing retaining walls and a discussion of relative economy of different forms of section.

The transition is a natural one from the complex subject of retaining walls to the allied but more definite one of masonry dams, treated in the last chapter. The conditions of stability are fully presented and also the methods of applying them to determine the dimensions of low dams. The high dam of economical section, with its familiar curves, is portrayed, and an algebraical process deduced for determining its proportions. The essential feature of this is, beginning at the top to design a series of trapezoidal sections in succession to the base, the base of one being the top of the one below, and the total to any depth being stable for the water pressure above that depth. Professor Merriman states that he selected this treatment, essentially like Wegmann's, from among others, as being simplest.

It is to be regretted that he did not also give Bonano's interesting application of the graphical process, which Wegmann applied to the Quaker Bridge dam.

A statement of the theoretical dimensions for this most important design, as determined by the engineers of the New York Aqueduct Commission, is given in the closing pages of the book.

J. L. G.

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BULLETIN OF ALUMNI AND COLLEGE NEWS.

The Annual Meeting of the Alumni Association was held at No. 12 West Thirty-First Street, in the Hall of the American Society of Mechanical Engineers, on Thursday evening, January 12, 1893. In the absence of the President, the chair was taken by Mr. Jno. A. Church. The special committee on a memorial fund to create a Trowbridge Fellowship in the School of Mines for research in engineering reported, through Prof. Monroe, the chairman, that nearly $3000 had been subscribed from less than a hundred members, and that the committee had good hope of success in their undertaking.

The tellers reported the election of the officers nominated, so that the officers of the Association for 1893 are:

President.—Wm. Barclay Parsons.

Vice-President.—Elwyn Waller.

Treasurer.—Alfred J. Moses.

Secretary.—F. R. Hutton.

Managers (terms expire 1893).—S. W. Andrews, '90; I. B. Johnson, '79; W. P. Butler, '78; Jno. A. Church, '67.

(Terms expire 1894.)—Edwin P. Clark, '80; D. LeR. Dresser, '89; Edward G. Love, '76; Wm. Allen Smith, '68.

The treasurer reported a favorable condition of the finances, showing a cash balance of $386.28 and a reserve fund in savings banks of $704.09. The Chairman of the Quarterly Board reported the purchase, upon terms favorable to the association, of the shares in that enterprise held by the student societies of the school, and this action was approved and confirmed by the association. Messrs. Moses, Waller, Greenleaf, Peele, Kemp and Struthers were appointed as editors for the ensuing year.

A proposition was made that a dinner be given to the president of the college by the university or graduate schools, and a committee of three was appointed to confer with similar committees of the other schools in this matter with power. The meeting then adjourned to a collation in the banquet-room of the hall.

Prof. Kemp was appointed a committee to draft resolutions relative to the death of Prof. Newberry, and he submitted the following:

"The members of the Association of the Alumni of the School of Mines, Columbia College, have learned with profound sorrow of the death of Professor J. S. Newberry, who for more than twenty-five years has occupied the chair of Geology and Palæontology.

"Dr. Newberry came to the School of Mines in 1866, and was the eighth appointment on its faculty. He brought with him a preparation for his work that was as thorough as it was far-reaching. His youth had been passed in the coal regions of Ohio, in the atmosphere of mining. After graduation from college and medical school, European study and travel had claimed him for two years. The practice of medicine occupied him on his return, but before long he was drawn away by love of scientific work, and was appointed surgeon and naturalist in the service of the national government, and was attached to exploring ex-

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peditions in the West. During the Civil War he was secretary of the Sanitary Commission, and was in charge of its operations in the valley of the Mississippi. He had also filled the chair of geology in the Columbian University of Washington during his winters at the Capital. All this varied experience—scientific, executive, professional, was at once utilized in building up the School of Mines, and with the world-wide reputation that had already come as the reward of investigation and writing, helped to make Dr. Newberry one of the strongest contributors to the success of the institution.

"As a man of science he was distinguished for his broad and keen insight and his ability to draw wide-reaching conclusions from the data in hand. His judgment on obscure and disputed points was conservative and temperate, while his accuracy of observation was remarkable.

"But it is as teacher and friend that old students at the School of Mines love best to think of him, for to them he ever manifested the kindliest interest and warmest friendship. Whether in the relations of the class-room or of later life, he was universally regarded by them with affection and respect. The members of the Alumni Association in expressing their own profound sorrow, can thus most appropriately convey to those who stood most closely related to him, the sympathy which they feel at his loss."

Resolved, That this memorial be spread in full upon the records of the association.

Resolved, That the secretary of the association be requested to transmit a copy of this action to the family of Professor Newberry.

Alliance with the Teachers' College.

After July 1st, 1893, all instruction in the Teachers' College in courses leading to a degree is to be under the control of the Faculty of Philosophy of Columbia College, and the president and certain professors of the Teachers' College will be entitled to seats in this faculty during the consideration of questions relating to the Teachers' College.

The courses of instruction given in Columbia and the Teachers' College and the libraries are to be open to male students in both colleges under suitable regulations.

It is stated that land near the new site has been secured by the Teachers' College for new buildings.

A similar alliance between Barnard College and the Teachers' College is in contemplation.

Engineering Department.

The committee on the reorganization of this department, appointed by the faculty, have completed their labors and the Board of Trustees has confirmed their recommendations. The old unit department has been divided into its several specialties as the growth and requirements of the profession have made expedient, and the three separate departments of Civil, Mechanical and Electrical Engineering have been created from it. To the chair of Civil Engineering Prof. Wm. H. Burr has been appointed; and Profs. Hutton and Crocker have been put at the head of their respective departments.

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Prof. William H. Burr graduated from the Rensselaer Polytechnic Institute in 1872, and was then for three years engaged with a bridge company in New York, and on the water supply and sewerage system of Newark, N. J. He then became a member of the faculty of the Rensselaer Polytechnic Institute as assistant professor and Professor of Rational and Technical Mechanics for nine years and during that period published his well-known book on "The Stresses in Bridge and Roof Trusses, Arch Ribs and Suspension Bridges," and "The Elasticity and Resistance of the Materials of Engineering." He also acted during this period as consulting engineer to the Delaware and Hudson Canal Company, the water-works and sewerage systems of Lansingburg, N. Y., etc. In 1884, when the formation of the Union Bridge Company caused the organization of the Phœnix Bridge Company, he accepted the position of Engineer of Construction of the latter, and subsequently became general manager. It was under his supervision that the large bridge structures of that company (among them the Chesapeake and Ohio bridge at Cincinnati, the Red Rock cantilever, the Pecos viaduct, etc.), were designed and executed. In April, 1891, he became Vice-President of Sooysmith & Co., consulting and constructing engineers for bridges, bridge foundations and pneumatic subaqueous work, tunnels, etc. He has also been associated with Mr. Alfred P. Boller, consulting engineer of New York City, on the large bridge now being built by that city across the Harlem River. In 1891 he became Professor of Civil Engineering at the Lawrence Scientific School, and leaves there at the end of the summer term to come to the School of Mines. He will have charge of the Summer School in Surveying for 1893.

Prof. R. S. Woodward, of the U. S. Coast and Geodetic Survey, has been called to the Chair of Mechanics, made vacant by the death of Prof. Peck. Both professors begin work at the college in the fall.

In the redistribution of subjects and instruction, to Prof. Hutton has been assigned the preliminary drawing work of the first and second year, which attaches Messrs. Mayer and Woolson to this department, and the third and fourth class work which belonged in the old organization to the mechanical side, including railway machinery. To civil engineering has been assigned the work of foundations and masonry, bridges, and braced structures, sanitary engineering, rivers and harbors, water supply, civil engineering design and railway permanent way; to the Electrical Department attach the special subjects germane to it.

The Department of Mechanics will undertake hereafter the instruction in Hydromechanics, which has been given in the Engineering Department in the fourth year. This will be done in the third year.

Sundry changes in the engineering courses have been made and planned, pursuant to the plan of getting preliminary instruction as early as possible, so as to release the fourth year for applications of mechanics to practice in engineering. Stoney on Strains, and Mechanics are to be completed in the third year, ore-dressing will be in the third year. electrical engineering for civil and mining engineers will be in the third year, physics will be completed in the second year, calculus will be begun in first term of second year and for some courses mechanics will be begun in second year. These changes ought to work to signal advantage in more evenly distributing the work of the several years.

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Department of Mechanics.

The Trustees, at the adjourned meeting held January 23d, separated the subject of Mechanics from the Department of Astronomy, thus creating a Department of Mechanics. To this new department they called R. S. Woodward, C. E., who is to take charge of the work after July 1, 1893.

In making such a choice the authorities are to be congratulated. Mr. Woodward is a graduate of the University of Michigan in the course of civil engineering—class of 1872. Since his graduation his work has been done in the government service mainly—in the Lake Survey, the Geological Survey and the U. S. Coast and Geodetic Survey. His investigations have been numerous and important.

In the January number of the *American Journal of Science* he has given an admirable description of the new "iced-bar base apparatus," upon which he has been working for a number of years.

For a couple of years he was a professor at the Columbian University at Washington, D. C., resigning because his original work took up so much of his time.

Professor Woodward appreciates fully the great importance to the engineers of a knowledge of mechanics, and his aim will be to make the fundamental work thorough; at the same time he will develop the higher work, and in this he will be ably assisted by Dr. Pupin.

Department of Electrical Engineering.

The Electrical Engineering Department was made a separate department at the January meeting of the Trustees and Adjunct Professor Crocker was promoted to a full professorship.

Several of the most novel and interesting pieces of electrical apparatus have been recently added to the collection. Among these are three motor dynamos for transforming direct currents from higher to lower voltage or vice versa. Such machines are now being largely introduced into practical work and are also very useful for experimental purposes. A direct-current dynamo of very high electromotive force (5500 volts) has been in successful operation in the laboratory for several months and has given interesting results. A larger machine, designed by Prof. Crocker to give 10,000 volts is almost completed, and will be the highest voltage direct-current dynamo ever built. A special transformer giving 80,000 volts alternating current has just been purchased by Dr. Pupin.

These new additions are specially important, since it is with light-voltage and high-frequency currents that the greater progress is now being made in electrical science.

Miscellaneous Notes.*

The Trustees accepted the offer of Joseph F. Loubat, to present to the College the sum of seven thousand dollars, the income to be devoted to the purpose of giving prizes for works in the English language on the history, geography, archæology, ethnology, philology, or numis-

* Chiefly from *University Bulletin*, No. 4.

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matics of North America, and also his further offer to present the sum of fourteen hundred dollars as a fund for prizes to be given in the year 1893.

The President was authorized to expend a sum, not exceeding $1000, for lectures in the Department of Engineering, during the current year, on River and Harbor Improvements, Water Supply and Sewerage of Towns.

University Council.

The University Council consists of the President, the Deans of the several University Faculties, and a representative chosen by each Faculty for the term of three years and of the Dean and Secretary of the School of Arts, *ex-officio*.

The Council has power in all matters not referred by statute to the President or the several Faculties:

To determine the conditions upon which the degrees of Master of Arts and Doctor of Philosophy shall be conferred, and to recommend candidates for the degrees.

To secure the correlation of courses offered by the several University Faculties; to encourage original research; to adjust all questions involving more than one Faculty.

To make such recommendations concerning the educational administration of the University as may seem to it proper, and to advise the President upon such matters as he may bring before it.

To prescribe the form of the Commencement exercises and to select the speakers.

To appoint all Fellows and to make rules for their government.

The Library.

The number of volumes in the library at present is about one hundred and forty-seven thousand. This does not include the Struve and Temple Emanu-El libraries.

The library of Dr. Struve, formerly director of the Observatory at Pulkowa, Russia, was bought and has arrived in good order.

The Temple Emanu-El on Fifth Avenue, in this city, presented to the College their collection of books on Hebrew literature, philology, and religion, numbering about twenty-five hundred bound volumes and one thousand pamphlets.

Summer School in Surveying.

Students in civil and mining engineering, metallurgy, and geology are required to attend the course, extending over two summers.

In that time they complete thirteen different surveys and exercises, with their computations and maps. Pacing, the chain, the steel tape, the compass, the transit, the telemeter rod, the level, the plane table, and minor instruments, the student becomes familiar with, by actual practice, repeated until he can do good work and appreciate it. The farm survey, the accurate and approximate methods of traversing, the mining claim, the city survey, topographical surveying of a small district in great detail, and of a large region in a more comprehensive style,—all are accomplished by the students before they leave.

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In order to ensure thorough work, the class is divided into squads of two men, and a separate survey assigned to each squad, so arranged that the men must depend upon their own work solely. This most necessary condition for real and not merely apparent efficiency of instruction is further maintained by an elaborate system of checks, whereby the officers can ascertain to a certainty how nearly correct the student's field and office work is, and can distinguish between accidental errors and careless work. For this purpose, what is known as the traverse-field is accurately surveyed by the officers. Some three hundred courses and corresponding angles, forming a network over the farm, have been laid out with great accuracy and marked by granite monuments, and the students' surveys are outlined upon these.

A new feature was introduced during the last season consisting of contour sketching over an extended area. Each squad was given an area three and one-half miles square, and required to sketch in twenty-foot contours upon it.

Another feature of the last session of the School was a relation with the United States Geological Survey, whereby many of the students gained the opportunity of experience and contact with the government survey party. Through the courtesy of Major Powell, chief of the survey, and with the cordial co-operation of his officers, arrangements were made whereby the students had the opportunity of going in parties of two to join the various topographical parties working in New York and the New England States. They were distributed between the Catskills, the Mohawk valley, the White Mountains, and Maine, each party spending from six to ten days watching the operations of the survey, and in some instances taking part in the work.

It is the intention hereafter to have the fourth-year students go to the Summer School for a period of three weeks, and there make all the surveys and estimates for the location and grading of a complete line of railroad of several miles in length.

MISCELLANEOUS.

A prize of $100 has been offered by Mr. William G. Low for the best essay on:

"The History and Progress of Civil Service Reform in the National, State and Local Governments of the United States."

Competition is open to all members of the University. The essay must not be less than 15,000 words in length, and must be submitted to the President on or before May 1, 1893.

The department of Greek has been enriched by an extensive and unique system of electrotypes, made by Professor Rood from sealing-wax impressions taken by Dr. Young from the Archaic gems and seals of Mycenæ and Baphio, now in the Polytechnikon at Athens.

As the nucleus of a collection of models to illustrate the development of the drama, Professor Brander Matthews has presented to the College a model of the stage and the scenery used at Valenciennes, in 1547, for the performance of the "Mystery of the Passion of Our Lord." This is a copy of the model made by order of the French Government for the special theatrical exhibition in connection with the Paris Exposition of 1878.

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Mr. A. B. Moldehnke has just acquired a complete set of Assyrian type; this is the only set of such type in the country. Mr. Moldehnke has placed the type at the disposal of Professor Gottheil, who intends to print a number of Assyrian text for use in his classes.

The small fire-proof Observatory to be used for latitude observations has been completed through the liberality of President Low and friends of the College

The large Moss Herbarium of Dr. Jaeger. containing 3100 species, has been secured for the Columbia Herbarium by the contributions of several persons interested in Botany.

Columbia College lectures in co-operation with the Metropolitan Museum of Art, to be given at the Museum, Fifth Avenue and Eighty-second Street, on Saturday mornings, at 11 o'clock.

The first course will be on "Styles in Fine Art," and will be delivered by Mr. Russell Sturgis, President of the Architectural League. "How Styles Originate and Grow. How Styles Differ. How Styles Express Purpose and Construction. How Styles Express External Nature."

The second course will be on :

"Cypriote Sculpture Illustrated by Greek Art," to be delivered by A. C. Merriam, Ph.D., Professor of Greek Archæology and Epigraphy.

"Methods of Engraving Gems, Used by the Ancients," to be delivered by Ogden N. Rood, A.M., Professor of Physics.

"The Transition from the Classical to Mediæval Architecture," to be delivered by W. R. Ware, S.B., Professor of Architecture.

"Architectural Forms of the Early Renaissance in France and Italy," to be delivered by A. D. F. Hamlin, A.M., Adjunct Professor of Architecture.

The third course will be on "The Mineral Resources of the United States," and will be given by J. F. Kemp, E.M., Professor of Geology.

A course of twelve lectures on "Physical Geography," will be given by Mr. G. K. Gilbert, of the United States Geological Survey, and President of the Geological Society of America, in the Geological Lecture Room, fourth floor, School of Mines Building.

The subject of these lectures are as follows:

General view of the processes by which the earth's surface is modelled. The work of water: disintegration, transportation, corrosion, deposition, base-level plains. The work of glaciers. The work of wind. The work of wind-waves. The methods of research. Illustration of research method. Organization of the United States Geological Survey.

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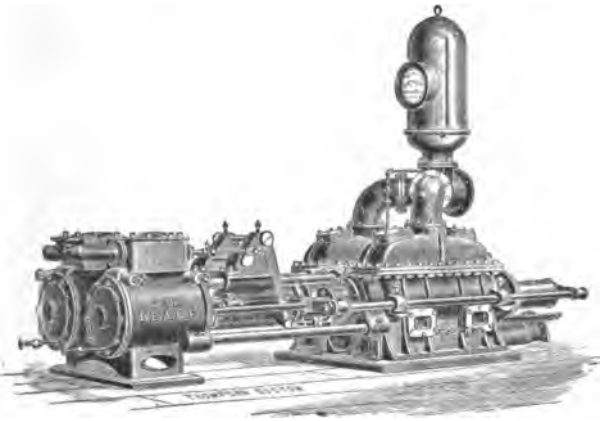

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Columbia College
In the City of New York.

COLUMBIA COLLEGE IN THE CITY OF NEW YORK at the present time consists of the School of Arts, the original college, founded in 1754; of sundry professional schools, to-wit; the School of Law, the School of Mines, and the College of Physicians and Surgeons, admission to all of which, as candidates for professional degrees, is open to all students whether or not they are college-bred men; and of the University Faculties of Law, Medicine, Mines (Applied Science), Political Science, Philosophy and Pure Science, which conduct all courses leading to the university degrees of Master of Arts and Doctor of Philosophy.

The point of contact between the college and the university is the senior year in the School of Arts, during which year students in the School of Arts pursue their studies, with the consent of the Faculty of Arts, under one or more of the University Faculties.

I. THE SCHOOL OF ARTS.

The School of Arts, or the college proper, has a curriculum of four years' duration leading to the degree of Bachelor of Arts. Candidates for admission to the School of Arts must be at least fifteen years of age, and pass an examination on prescribed subjects, the particulars concerning which may be found in the annual Circular of Information.

II. THE UNIVERSITY FACULTIES.

The University Faculties of Law, Medicine, Mines (Applied Science), Political Science, Philosophy, and Pure Science, taken together constitute the University. These university faculties offer advanced courses of study and investigation, respectively, in (*a*) Private or Municipal Law, (*b*) Applied Science, (*c*) History, Economics, and Public Law, (*d*) Philosophy, Philology and Letters, and (*e*) Pure Science. Courses of study under one or more of these university faculties are open to members of the senior class in the School of Arts and to all students who have successfully pursued an equivalent course of undergraduate study to the close of the junior year. These lead through the Bachelor's degree to the university degree of Master of Arts and Doctor of Philosophy.

III. THE PROFESSIONAL SCHOOLS.

The professional schools are the Schools of Law, Mines, and Medicine, to which all students, as well those not having pursued a course of undergraduate study as those who have, are admitted on terms prescribed by the faculty of each school as candidates for professional degrees.

1. The School of Law, established in 1858, offers a course of study covering a period of three years, and designed to give full and accurate instruction in the principles and practice of private and public law. The degree of Bachelor of Laws is conferred on the satisfactory completion of the course, and in addition thereto the degree of Master of Arts is conferred upon college graduates who comply with the conditions prescribed by the University Council.

2. The School of Mines, established in 1864, offers the following courses of study, each of four years' duration, and each leading to an appropriate professional degree, namely, Mining Engineering, Civil Engineering, Electrical Engineering, Metallurgy, Geology and Palæontology, Analytical and Applied Chemistry, Architecture. The degree of Master of Arts is conferred upon college graduates who comply with prescribed conditions. There are, also, an additional course for graduates in Electrical Engineering, and a graduate course in Sanitary Engineering, each leading to an appropriate degree.

3. The College of Physicians and Surgeons offers a three years' course of study in the principles and practice of medicine and surgery, leading to the degree of Doctor of Medicine (M.D.).

SETH LOW, LL.D., President.

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JOHN MAGNUS ADAMS, A.M., E.M.,

THE FIRST GRADUATE OF THE SCHOOL OF MINES.

BORN JULY 18TH, 1845. DIED JUNE 25TH, 1892.

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THE

SCHOOL OF MINES QUARTERLY.

VOL. XIV. APRIL, 1893. No. 3.

In Memoriam.

JOHN MAGNUS ADAMS.

THE FIRST GRADUATE OF THE SCHOOL OF MINES.

THE School of Mines first opened its doors for instruction in the fall of the year 1864. Its first year was regarded solely as an experiment by the trustees and a few rooms in the basement of the old building (now torn down), were used in that year both for instruction, and for laboratory work. At the beginning it possessed only the most ordinary equipment as to laboratories and instruction, and it began with only three regular professors. The instruction of these professors was supplemented by lectures by the regular staff of the college.

One of the first applicants for admission to the new school, was John Magnus Adams, who had just graduated from Columbia College with honor in the class of 1864. As he was destined to become the first graduate of the School of Mines, and as he has now gone from us, it seems peculiarly fitting to present in the SCHOOL OF MINES QUARTERLY, a few memoranda as to his life and professional work.

John Magnus Adams was the son of the late William Adams, a New York commission merchant. He was born at his father's country place in the Catskills, on July 18, 1845. He was the

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grandson of John Adams, who came from the North of Ireland at the beginning of this century, and who, for many years prior to his death was the President of the Fulton Bank, New York City. On his mother's side he was the grandson of Charles Gustavus Smedburg, a native of Sweden, who came to New York at the beginning of this century and his middle name was that of his great grandfather, Magnus Smedberg, of Stockholm.

As a child Adams was a delicate boy with a very large intellectual head. First, in the infant school of Miss Ripley in Twenty-Seventh Street, and afterwards in the classical school of Mr. Leggett, at Broadway and Twelfth Street, he excited the interest of his teachers by his untiring perseverance in everything he took hold of. He was not quick in his studies, but remarkably steady and earnest and these traits kept him always at the head of his classes. His lack of physique gave his family much uneasiness during his childhood, and he was early encouraged to spend as much of his spare time in the open air as possible. His love of fishing and shooting, began as a boy during the long vacations in the Catskills, and even when a mere child he would start out for an all day tramp with his gun. Being near sighted his success was not very remarkable at first, but by sticking to it he became a very fair shot indeed and at the same time made himself strong and robust in frame. He entered Columbia College when fifteen years old, and throughout his four years' course ranked third in his class. In the fall of the year in which he graduated in the college, he entered the School of Mines. As to his career in the school one of his professors writes: "Adams was one of the first to enter the School of Mines, and from the date he entered it, he was never behind-hand in anything. He was always prompt and intelligent, and worked steadily without making any great show of it. He never failed at a single examination. His marks were generally above eight, and he had but one mark of six in his whole course, and that was in drawing, for which he was not to blame, for as you can remember, the facilities in that department were not good, even in your time." (1866–1869.) In March or April, 1867, having an offer of employment in the west, Adams was permitted to take his graduating examination, before the rest of his class. As to this examination one of his class-mates writes: "I remember that he passed a brilliant examination. He was the first to graduate, the first to receive permanent professional em-

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ployment, and the first to go into the technology of the precious metals."

In May, 1867, he sailed for California by way of Panama to enter the employment of the New York and Owyhee Gold and Silver Mining Company of Silver City, Idaho, as metallurgist and amalgamator. This company owned the celebrated Poor Man Lode, and the problem offered by the ores of that property being a very difficult one, he had been recommended by the authorities of the School of Mines as the best man to solve it. On his way to Idaho, he examined the Belcher and other properties on the Comstock Lode for New York parties. From the moment of his arrival at Silver City, he operated the mill of the company successfully, and within two years he had reduced the loss in tailings to a minimum, and the loss of mercury more than one-half. In 1870 he was made full superintendent, with W. F. Carter in charge of the mechanical department. They continued this arrangement until 1872, when they leased the Elmore and Cosmos properties and the New York mill. These leases were profitable up to the end of 1873, when they sold out their Idaho interests, and Adams returned to New York to spend a period with his family. During these years he had made himself the best mill man on the Pacific Coast, and had improved the Washoe process both by lessening its cost and by decreasing the losses. The experience of these years in Idaho, he embodied in a paper for the American Institute of Mining Engineers, at the February Meeting, 1874, entitled "The Treatment of Gold and Silver Ores by Wet Crushing and Pan Amalgamation Without Roasting," which was republished the same year in the Annual Report of the U. S. Commissioner of Mining Statistics, under the title, "Hints on the Washoe Process." Although since that date the practice of milling has changed in many regards, Adams's paper is still often referred to, and it is not saying too much to state that its influence on this branch of metallurgy was very great.

In May, 1874, Adams was called up to the Silver Islet Mine on the North Shore of Lake Superior to test the very complex ores of that mine by the Washoe process. For this purpose he erected a small plant at Detroit, and was very confident that the Washoe process would solve the problem. His results were excellent, but the local conditions existing at that time at the Silver Islet Mine were difficult and it soon became evident that in order to use the

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Washoe process, it would be necessary to bring the ores in bulk to Detroit for treatment at very heavy freight rates, and consequent loss of profit. Captain Frue, the superintendent, had at that time evolved the idea of what is now known as the "Frue Vanner," namely, a revolving belt with a side shake, and Adams after experimenting with it came to the conclusion that concentrating in loco with the Frue Vanner, and shipping concentrates and mass-ore to Detroit for smelting offered greater advantages than could be obtained by shipping raw ore and milling at Detroit. This solution of the problem gave perfectly satisfactory results until the Silver Islet Mine ceased to be a producer.

Much impressed with the value of the Frue Vanner for concentrating, Adams applied for the agency of it for the Pacific coast, and formed the firm of Adams & Carter, of San Francisco, for the purpose of introducing it. For the first few years they encountered many prejudices and spent much money in overcoming them, but finally a successful business was established which continued up to Adams' death. In connection with Mr. Carter several improvements of details of mechanism were made, and their business became a large one.

Adams married Miss Sallie Haskell in March, 1881. His wife was both beautiful and good, and their married life was a very happy one. Having no children she sympathized in all his tastes and when he projected a fishing excursion she always went with him, and it was always a question as to which caught the most fish, for they were both very successful. Mrs. Adams was also a wonderful off-hand pistol shot, and the walls of her house were decorated with many brilliant wings of birds which she had shot. Seldom can one meet a more happy and hospitable pair, and all School of Mines men who came to the coast were warmly welcomed by them to their lovely home. Mrs. Adams died on the 10th of March, 1886, after five years of marriage, and her death was an irreparable loss to her husband, who never recovered from it. In the same year, and but a few months later, his partner, Mr. Carter, died suddenly. The business was carried on without change of firm name through the purchase of Carter's interest from his heirs.

Early in June, 1892, feeling ill and unfit for work, Adams decided to make one of his fishing trips to a favorite point on the Reservation of the Klamath Indians in Southern Oregon. He left San Francisco unwell, and was hardly equal to so wearing

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a journey, but he longed for the streams and woods, and thought that a return to them would restore him to health, as it had done on other occasions. He was accompanied by two old friends and his trusted Indian guide Joe Coburn met him on leaving the railroad to take them to their camping place 100 miles from the line. Hardly were the party established in camp when Adams became seriously worse, with the complication of catarrh and pneumonia which he had in San Francisco. Physicians were summoned, and he was moved with difficulty to the residence of the Indian agent, where he passed away peacefully at 2 o'clock on the morning of June 25th. His body was taken to San Francisco and funeral services were held in the first Presbyterian Church on June 29th. From the pulpit, which was embowered with palms and flowers, his old friend Dr. McKenzie delivered the funeral sermon. The church was crowded with his many friends, and many were unable to gain entrance. At the time of his death Adams was a member of all the principal clubs of San Francisco, and an officer in several of them, and his death caused a very widely extended sentiment of sorrow, for he was loved and respected by many.

Adams was the first graduate of our School of Mines, and through his whole life he led the van of those, who by their hard work, unflinching honesty and professional skill have caused School of Mines graduates to be to-day respected in all parts of the world. His professional judgment both as to mines and the treatment of ores was very conservative, and it was continually sought during his whole career both in valuing mines and in testing new processes and machinery. Members of the profession often sought his advice in designing new mills, and his vast experience and sound judgment were of great value to them. In everything he did he was thorough. He was faithful in his friendships, honest in his purposes, generous, warm-hearted and truthful. What he put his hand to do he accomplished, and it was always well done. His word once passed could always be relied on, and when he stated that he believed a thing to be so or thus, it would always prove to be as stated.

Probably no man ever graduated from the School of Mines, so generally loved, respected and trusted by all who knew him. He was buried beside his much loved wife in the Masonic Cemetery, San Francisco.

JOHN C. F. RANDOLPH.

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STANDARDS OF LINEAR MEASURE.

By EDWIN P. CLARK, E.M.

(Continued from p. 133.)

THE first settlers of the English Colonies in America brought with them the general laws, customs and usages of the mother country, and made use in all their transactions of the English measures and weights. In all the colonies, customs arose or laws were enacted establishing the "standards of the Exchequer" as the lawful measures and weights, the standard yard being that of Queen Elizabeth of 1588. Actual copies were obtained, in many instances, of the standards of the old country, and the office of sealer of weights and measures, or some similar office with analogous functions, established in all the colonies. From the absolute inter-independence of the colonies some diversity of standard arose prior to the Revolution, but there was substantial uniformity.

The Congress of the United States is empowered to "fix the standard of weights and measures,"* but has never directly established any standard of linear measure. The journals of both Houses of Congress show that committees were early appointed to consider the subject. "In July, 1790, Thomas Jefferson, then Secretary of State, in obedience to a resolution of Congress calling upon the Secretary to propose a plan for establishing a uniformity in the currency, weights and measures of the United States" (in conformity with the suggestion of Washington in his annual message, in which he said, "Uniformity in the currency, weights and measures of the United States is an object of great importance, and will, I am persuaded, be duly attended to") "recommended in his report a decimal system of metrology, and that the unit be derived from a natural and invariable standard of length." He was not satisfied with the results obtained in measurements that had, up to that time, been made of portions of great circles of the globe, or with the simple seconds pendulum, and therefore "advised the use of a seconds rod of 5 feet, known as Leslie's pendulum rod. This was a simple straight bar, without a bob or disc, suspended at one

* Constitution, Art. I., Sec. 8, paragraph 5.

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end, and free to swing at that point, its centre of oscillation being at a distance of two-thirds of its length from the point of suspension. It would be one-half longer than the ordinary loaded pendulum." "He proposed that this rod be made of iron, of such a length that at the level of the sea, at latitude 45°, and with a constant temperature, it should beat seconds of mean time; its length would be 58.72368 inches." Jefferson proposed to divide this into 5 feet of 10 equal parts each. This would give a foot equal to 11.7449 British inches.* It is probably needless to say that nothing ever came of this proposition.

In 1813, the Coast Survey, in order to have a well-accredited copy of the British standard, procured a Troughton scale 82 inches long, of substantially the same pattern as that used by Shuckburgh. With this as a comparateur, Mr. Hassler, Superintendent of the Coast Survey, made a large number of comparisons of all the standard measures that he could obtain, as well as the different parts of the scale with itself. The result of the latter experiment was the determination that the 36 inches comprised between the 27th and 63d inches of the scale at 62° F. should be the standard yard; this was afterwards adopted by the Treasury Department as a standard. Mr. Hassler also determined the length of the metre and toise, in his comparisons made in 1817. His results were: metre equal to 39.38024797 inches; toise, 76.74 + (comparison of 4 toises not averaged and not considered conclusive by Mr. Hassler).†

On March 3, 1817, the Senate, by a resolution of that date, directed the Secretary of State to prepare and report to it "a statement relative to the regulations and standards for weights and measures in the several States, and relative to proceedings in foreign countries, for establishing uniformity in weights and measures, together with such propositions relative thereto, as may be proper to be adopted in the United States." The report of John Quincy Adams, quoted several times in this article, was the result of this resolution. In this report Mr. Adams displayed a large amount of erudition, and collected together all the information that he could obtain on the subject. He discussed very thoroughly the

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* Geo. M. Bond, *Jour. Frank. Inst.*, 107, 3d ser. 87, pp. 283-4.

† J. Q. Adams, Report, Append. D, pp. 154, *et. seq.*

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old English standards and the French metric system, as well as the theoretical question of uniformity, but practically recommended that nothing be done to change the generally accepted system as then existing in the United States, especially as it substantially agreed with the British system. He advised that Congress should request the President to communicate with foreign governments looking to concerted action for the eventual establishment of a universal uniformity; in the meantime Congress to fix and determine the standards in use in the various States as nearly as possible by means of their theoretical values and the English standards. He collected in the appendices of his report all the laws that had been enacted by the various colonies and States relative to the subject of measures and weights. No legislative action followed this report.

The next attempt looking towards a regulation of the subject was a resolution of the Senate of May 29, 1830, directing the Secretary of the Treasury to have the various measures and weights in use in the custom houses of the United States compared and inspected so that uniformity might be introduced. Accordingly Mr. Hassler conducted another series of experiments in 1831, a detailed account of which is contained in a report made to the Senate in 1832. He did not confine his comparisons to the measures sent in by the custom houses, but also made use of all standards that could be procured, some of which he obtained from the various national and State governmental departments, and some from private sources.

The principal standards of linear measure that he compared were the following:

I. The Troughton Scale of the Coast Survey Department made in 1813. This was the standard by which all the others were measured.

II. A brass line measure having the yard and ell marked on it, authenticated "by a parchment indenture, stating" that it had been "received from the Exchequer by Edward Abraham De Grave, No. 59 St. Martin Legrand, sealer, weight and measure maker, dated 8th Dec., 1820; and a certificate of Thomas Jones, mathematical instrument maker, etc., that" it was made "under his direction, dated the same day."

III. and IV. End measures of the yard and ell made by Thomas

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Jones, authenticated by a similar indenture, dated May 27, 1822, having engraved inscriptions certifying them as exact copies of the Exchequer standard of 1601 (Elizabeth 1588?) at 62° F., made expressly for the Government of the United States in May, 1822.

V. A brass scale or rule, having the yard and ell marked by lines or stripes of silver; made by Jones.

VI. A scale of 52 inches made by Troughton which had marked on it the distance 51.2 inches taken from Shuckburgh's scale.

VII. A yard between platinum dots, also made by Troughton, and considered to be identical with the old Exchequer yard. On it was marked the old Amsterdam foot.

VIII. A scale belonging to the University of Virginia, made by Gilbert.

IX. An iron yard of the Engineer's Department, cut to length by Troughton.

X. A brass yard from the office of the Secretary of State of New York, procured from the Exchequer in 1803.

The results obtained are shown in the following tables:

		Inches.
II.	The old Exchequer yard of 1820,	35.987497
	" " ell "	45.026101
	The latter reduced to the yard,	36.020881
III.	The copy of the Exchequer yard by Jones,	35 9990285
IV.	The copy of the Exchequer ell by Jones,	45.0389644
	The latter reduced to the yard,	36.031171
V.	The brass yard of Jones,	35.993835
	The brass ell of Jones,	45.03343
	The latter reduced to the yard,	36.026744
VI.	The Troughton yard (mean of the 52 ins. scale),	36.0002465
	The 51.2 ins., taken from Shuckburgh's scale),	51.1992977
	The yard reduced from the latter proportionally,	35.999506
VII.	The yard between platinum dots,	35.9989758
	The Amsterdam foot laid down on the same,	11.30346
VIII.	The scale of the University of Virginia,	35.9952318
IX.	The iron yard of the Engineer Department,	35.998776
X.	The New York brass yard,	36.01545

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Measures sent in by the Custom Houses.

A folding yard rule, Philadelphia,	36.0002465
A sixty-inch tape, Philadelphia,	59.6
A yard stick, Boston,	36.02581
A " Baltimore,	36.0156
A yard tape, Baltimore,	36.05
An octagon 48-inch stick, Richmond,	48.12
Brass foot-rules, Providence:	
No. 1. 12.026 ins.; resulting yard,	36.078
No. 2. 12.055 ins.; "	36.165*

"In the year 1856 the British government presented to the United States two authentic copies of the British standard of length which are known in Washington as: Bronze Standard No. 11, and Low Moor Iron Standard No. 57. Both are bars of square cross-section and somewhat longer than a yard; in the vicinity of each end there is a circular hole sunk down to the center of the bar, into the bottom of which a small gold disc is inserted, on which are engraved five fine lines, viz., two in the direction of the length of the bar and three at right angles to them. The length of one yard is defined by the distance from the central transverse line in one hole to the central transverse line in the other hole, the parts of those lines to be used which are situated between the two longitudinal lines. The standard temperatures were given by Mr. Airy, the Astronomer Royal, for the bronze bar at 61.79° F., and for the iron bar at 62.58° F. The object of locating the graduation of these standards in the neutral axis of the bars was to eliminate the error resulting from flexure† unavoidably due to the weight of the bar between the points of support, when used in comparisons. When these standards were compared with the Troughton scale it was found to be too long by .00083 inch at 62° F., and its standard temperature was corrected to 59.4°. In 1874 it was again corrected to 59.6° F. It has since been found that bronze No. 11 is shorter by .000088 of an inch at 62° F. than the British Imperial yard, with which it was compared in 1878, and so its standard temperature was established at 62.25° F. From the conclusions of Mr. Hilgard it seems evident that standards are apt to permanently change their length in the course of time by being sub-

* F. R. Hassler, Report, *passim*.

† Giessler, *Journal Frank. Inst.*, 126, p. 122.

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jected to variations of temperature, and possibly independently of that cause, some molecular alteration seems to occur in the metal bars, especially those made of alloys such as Baily's metal, which changes their length. It was found that the two standards presented to the government in 1856 had changed their relative length by .00025 of an inch in twenty-five years. When these changes are satisfactorily proven to have taken place the temperature at which the bars will be the correct length is changed and they again become *standard.*

The ordinary forms of end and line standards have been described. They are, generally, plain metal bars of square or rectangular cross-section. "When measures constructed of different metals are compared with each other, careful measurements must be made of their temperature, so as to take into consideration their different" rates of expansion.* In order to obtain this value most accurately, standards have been constructed which form metal thermometers. The standard metre, presented by France to the United States in 1850, is one of these. It is a planed and polished steel bar, the two ends of which are a metre apart at 0° C. (32° F.). Upon each end of the bar is screwed a small steel prism of the thickness of half the width of the bar. The joints between the prisms and the ends serve as lines, and the standard is, therefore, a line measure as well as an end measure. This steel bar rests upon a thicker and somewhat longer bronze bar, the two ends of which project beyond it, the bars being united by a pin at one end, the other ends being free. To prevent any lateral deviation, there are four short guide-pieces, one on each side, attached to each end of the bronze bar, their top surfaces extending up flush with the top of the steel bar. One of the guide-pieces at the free end bears a graduation, and opposite to it the steel bar bears a vernier, by means of which the relative movements of expansion of the two bars can be read off to .01 mm. The standard is placed in melt-

* For detailed accounts of the methods and apparatus used in comparing standard measures, consult Hassler's Report, Chisholm "On Weighing and Measuring," Report of the Secretary of the Treasury on "Construction and Distribution of Weights and Measures," Washington, 1857, and the articles by Gieseler and Bond in the *Journal* of the Franklin Institute, referred to in this article. For a discussion of several important questions entering into the subject of comparison of standards, see an article "On the Present State of the Question of Standards of Length," by Professor W. A. Rogers, in *Proceedings* of the Amer. Acad. of Arts and Sciences, vol. xv. (new series, vii.), pp. 273 *et seq.*, which also contains a bibliography of the subject.

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ing ice for two hours, the vernier then reads 4.42; it is then placed in boiling water for two hours, and the reading is 3.80 mm.; the difference, 0.62 mm., being the relative difference of expansion for 100° C. for 954 mm., that being the distance from the fixed point to the zero of the vernier. In order to determine the absolute expansion of each bar, use is made of a beam-compass, the two points of which are kept at 1 metre apart by placing it in a trough of melting ice through the bottom of which the points protrude. By applying this beam-compass to the steel and bronze bars, at both ranges of temperature used in the first experiment described above, the following results are obtained:

Expansion of bronze bar, for range of 100° C., 1.7030 mm.

Expansion of steel bar, for range of 100° C., 1.0502.

The difference, 0.6528, reduced to the length of 954 mm., gives 0.6228, a very close approximation to the result first obtained.*

Congress has never, by direct legislation, established any standard of length, and has enacted very few laws bearing upon the subject. In the act providing for the survey and sale of the public lands northwest of the Ohio river, approved May 18, 1796, there is a provision that "all lines shall be . . . . measured with chains containing two perches of sixteen feet and one-half each, subdivided into twenty-five equal links, and the chain shall be adjusted to a standard to be kept for that purpose." Accordingly, a chain, 33 feet long, divided into double link lengths, was made in 1797, by Benjamin Rittenhouse, of Philadelphia, and first used at Marietta, Ohio, as a standard for adjusting measures used in executing the public surveys. In the act "to regulate the collection of duties on imposts and tonnage," approved March 2, 1799, which established rules and regulations for the custom-house service, section 21 prescribes that the surveyor of customs "shall also, from time to time, and particularly on the first Monday in January and July in each year, examine and try the weights, measures, and other instruments, used in ascertaining the duties on imports, with standards to be provided by each collector at the public expense for that purpose; and when disagreements or errors are discovered, he shall report the same to the collector, and obey and execute such directions as he may receive for correcting thereof, agreeably to the standards aforesaid." By joint resolution of June, 14, 1836, Congress directed the Secretary of the Treasury to distribute com-

* Giessler, *ibid.*, pp. 123-4-5.

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plete sets of all the weights and measures adopted as standards, and made for the use of the custom houses, to the various States of the Union, "to the end that an uniform standard of weights and measures may be established throughout the United States." This was accordingly done under the direction of the Coast Survey, the construction and comparison of the standards being made under the immediate supervision of Mr. Joseph Saxton. Another act was approved July 28, 1866, permitting and legalizing the use of the metric system; the length of the metre being established at 39.37 inches; the Secretary of the Treasury having been directed to furnish the States with sets of metric weights and measures by a joint resolution of July 27, 1866.

The *actual standard of length* of the United States, adopted by the Treasury Department and the Coast Survey, is the Troughton 82-inch scale, and the *standard yard* is measured between the 27th and 63d inches at the temperature of 59.60° F., although recourse is had to No. 11 and No. 57 whenever great precision is required. The United States standard yard is *identical* with the British imperial Yard, notwithstanding statements to the contrary to be found in some text-books, works on metrology, and kindred subjects. The statement is sometimes made, that the British standard is about 1 part in 17,230 shorter than the United States, which error appears to have arisen from the unfortunate relation of the yard to the seconds pendulum established by the act of 1824, which has since been shown to be erroneous. Other errors that have found countenance are, that one United States inch equals 1.000049 British inches, and that the American standard yard is .00087 inch longer than the British.

The legislation of the different Colonies and States on the subject of standard measures may well be typified by that of New York, which consists of the following acts.

Act of June 19, 1703.—Provides, "That from and after the first day of August," next "there shall be . . . . one yard, that is to say, ... according to the standard of her Majesty's exchequer, in the realm of England, throughout all this colony." Prior to the acquisition of the colony by the English, in 1664, the standard in use was the Dutch measure, founded on the Amsterdam foot, equal to 11.304 inches (11 30346 according to Hassler) British standard, 13 of which made a Dutch rod, equivalent to 12 feet 3.62 inches. This act also provides for the appointment of sealers of weights

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and measures in all the counties and cities of the colony, and prescribes their duties.

Act of Apr. 10, 1784.—Provides "That, from and after the first day of June next, there shall be one . . . . certain weight and measure; that is to say . . . . according to the standard in use in this State, on the day of the declaration of the independence thereof; and that the standard weights and measures in the custody of William Hardenbrook, who, before and at the time of said declaration, was the public sealer and marker of all beams, and weights, and measures, within the city and county of New York, which standard is according to the standard of the court of exchequer in that part of Great Britain called England, shall forever hereafter be deposited with, kept, and preserved by the clerk of the peace, or common clerk of the city and county of New York, for the time being, and shall be and hereby are declared and established to be and remain the standard, for ascertaining all beams, weights, and measures, throughout the State, any usage or custom to the contrary thereof notwithstanding; . . . . *Provided always*" That William Hardenbrook shall deliver the said standards to the clerk and declare on oath that they "are the same which he received from the court of exchequer." This act also provides that if any of the standards are broken, impaired or mislaid that the Common Council of New York shall cause them to be replaced by any other "standarded" weights or measures, "taking care that the same is according to the standard established in the" colony before the declaration of independence; also provides for sealers. Professor Renwick states it as his opinion that these standards, mentioned in this act, were lost at the time (1826) when he investigated the subject.*

Act of Feb. 2, 1804.—Constitutes the Secretary of State state sealer of weights and measures, and provides for county and town sealers, and also for standards to be made of iron, brass or copper and distributed.

Act of Mch. 24, 1809.—"Whereas the corporation of the city of New York did, in the year 1803, procure a brass yard measure, engraved and sealed at the exchequer in Great Britain, and have presented the same to this State, which has been deposited together with the documents authenticating it, in the secretary's office—

* *Journal Frank. Inst*, New Ser. 13 (17), p. 379.

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Therefore, *Be it enacted*," *etc.*, " That the said brass measure is and shall be, the standard yard measure of this State." Provides for properly engraving the standard, and making of copies for distribution among the several counties of the State. Also enacts that surveyors, in testifying regarding surveys shall make oath that the measure used by them was conformable to this standard; otherwise their evidence to be rejected. * This is the standard which Hassler compared (No. X) and found to be 36.01545 inches on Troughton's scale, although a copy deposited in the street commissioner's office in New York City and called by Mr. Adams the New York city yard was too short, being only 35.97 inches of the New York State yard, equivalent to 35.99 United States inches. †

Act of Mch. 19, 1813.—Provides " That there shall be . . . . one certain rod for long measure, according to the standard in use in this State, on the day of the declaration of the independence thereof; and that the standard of weights and measures, now in the office of the secretary of this State, which is according to the standard of the court of exchequer in that part of Great Britain called England, shall be, and is hereby declared to be and remain, the standard for ascertaining all beams, weights, and measures throughout this State, until the Congress of the United States shall establish the standard of weights and measures for the United States." Also enacts that the secretary of state shall be, ex-officio, State sealer of weights and measures; that there shall be three assistant State sealers. one for New York City, one for Albany, and one in the county of Oneida; also county and town sealers. Also prescribes regulations for procuring, distributing and properly marking and comparing the various State, county and town standards. Embodies the same clauses regarding evidence of surveyors found in the act of 1809.‡

The commissioners who compiled the first edition of the revised statutes referred the subject of weights and measures to James Renwick, LL.D., Professor of Natural Philosophy and Chemistry in Columbia College, who made a report to them in 1826. In this

* The acts above summarized will be found in Adams' report pp. 101–2, 189 *et seq.*

† Adams' Report, Ap. A 2, table after p. 140. Renwick, *Journal Frank. Inst.* 13 (17), p. 379.

‡ R. L., 1813, ch. 30 Van Ness and Woodworth, I., p. 376: repealed by-laws of 1828, 2d Sess., ch. 21, par. 98, to take effect December 31, 1829.

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report he discourages the idea of introducing any radical changes, and recommends that the standard yard in use at the time of the declaration of independence referred to in the previous statutes be defined by its relation to the seconds pendulum, some experiments with which had been conducted at the college by himself and Captain, afterwards General, Sir Edward Sabine, they having found the length of the pendulum to be 39.10158 inches, which gives the relation subsequently enacted. He recommends the enactment of a statute in almost the identical words afterwards employed. The result of this report was the following.

Revised Statutes, Part I., Chap. XIX., Title II. (1st edition).

SECTION 1. "There shall be but one standard of measure of length and surface," etc., ... "throughout this State."

SEC. 2. "The unit or standard measure of length and surface . . . . shall be the yard, as used in this State on the" 4th of July, 1776.

SEC. 3. "For the precise definition of the said yard, and in order to its recovery in case of loss, it is declared (until the measure of the pendulum shall be transfered to some appropriate public building) that such yard has been found, by experiments made with a pendulum, with a brass rod, at Columbia College" (the old site in College Place) "in the city of New York, in the latitude of 40° 42′ 43″ N., to bear to the pendulum of that place, vibrating seconds in a vacuum, at the temperature of melting ice the proportions of 1,000,000 to 1,086,141."

SEC. 4. "The standard yard thus defined, shall be measured in a straight line between two points engraved upon golden discs, inserted into a straight brass rod; and in case the same shall be lost, or otherwise destroyed, defaced, or injured, it shall be restored according to the proportions mentioned in the preceding section, under the direction of the secretary of state, as sealer of weights and measures."

SEC. 5. Prescribes that the yard shall be divided into three feet of twelve inches each, and for cloth measure into halves, quarters, eighths, and sixteenths; section 20 provides for keeping the standards in a chest under three locks, and they were only to be used for comparisons at certain stated times; and section 34 has the same regulations regarding surveyor's evidence as contained in

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previous statutes. This chapter of the revised statutes was repealed by laws of 1851, ch. 134, sec. 35.

The building in which the standards were kept was burned April 13, 1843, and as they were considerably injured, an act was passed the next year (L. 1844, ch. 70) empowering the Secretary of State to replace them.

The present law of the State of New York governing standards of length as contained in *Chapter* 134 *of the Laws of* 1851 is as follows.

SECTION 1. "The standard weights and measures now in charge of the Secretary of State, being the same that were furnished to this State by the government of the United States, in accordance with a joint resolution of Congress, approved June 14, 1836, and consisting of one standard yard measure" (sent from Washington, March 23, 1850), etc., etc., "shall be the standard of weight and measure throughout this State."

SEC. 2. "The unit or standard measure of length and surface from which all other measures of extension, whether they be lineal, superficial or solid, shall be derived and ascertained, shall be the standard yard designated in the first section of this act."

SEC. 3 provides for dividing the yard into 3 feet of 12 inches, and also into halves, quarters, eighths and sixteenths for cloth measure; section 4 establishes the rod, pole or perch at 5½ yards, the mile at 1760 yards, and the chain of 100 links at 22 yards; section 5 establishes the acre, to be "measured horizontally" at 10 square chains, or equivalent to a rectangle 16 rods long by 10 wide. The act also provides for the appointment of a superintendent of weights and measures to have charge of the standards and provide, compare and correct the various county, city and town standards which the act directs to be procured.

SEC. 33. "No surveyor shall give evidence in any cause depending in any of the courts of the State, or before arbitrators, respecting the survey or measurement of lands which he may have made, unless such surveyor shall make oath, if required, that the chain or measure used by him was conformable to the standards which were the standards of the State at the time such survey was made."

It is thus seen that there have been a multiplicity of standards, and that there are numerous varieties of the same standard, due,

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for the most part, to inaccurate copying from the original standard measure.

The practice of the art of measuring depends not only on the possession of an accurately standarded measure, but even to a greater extent upon the manner in which it is used, and the accuracy and care with which the measure is applied to the distance sought to be measured. The apparent inaccuracy of standard in various well-known distances is probably due more to the "personal equations" of the surveyors who laid them out than to any other fact. Steel tapes were unknown until within the last thirty or forty years; the chain of 100 heavy wire links, by being constantly dragged over the ground and through the woods, and by the wearing of the links at their point of contact undoubtedly became somewhat lengthened, and thus the distances measured were actually longer than indicated by the chain. It is said that one of the old surveyors of Albany was in the habit of measuring with his chain to the point of his elbow, and sticking in his measuring pin with his hand, thus adding about 15 or 16 inches to each 66 feet.

John McComb, architect of the New York city hall, and afterwards street commissioner, some time about 1802 or 1803 had a 10-foot rod made of Georgia pine, taken from the old Oswego market which stood at the head of Maiden lane, shod with iron at each end, which he used in laying out the work in the construction of the city hall. He probably standarded this rod as best he could from such means as were at his disposal. This rod is said to have been the foundation of the "New York City Standard," and was sometimes called the "Carpenter's Standard." McComb erected the iron tablet in the left-hand corridor of the city hall, and on it laid off 10 feet in "English measure" and "Amsterdam measure," leaving a space for "Federal measure," which was never supplied. By rough measurements made recently the 10 feet "English measure" was found to be 10 feet and .12 of an inch U. S., equivalent to 10.01 feet, and the "Amsterdam measure" 9 feet, 5.15 inches, equivalent to 9.4291 feet, Hassler's determination giving 9.4196 feet.

In New York City there are practically two standards. The "down-town" standard, used in laying out most of the city south of Fourteenth street, except the old Dutch town and a few old farms, which is about 1¼ inches longer in 100 feet than the U. S.,

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or 100.1042, agreeing very closely with the 10-foot length of the city hall tablet; and the "up-town" standard used by Randall in laying out Manhattan island above Houston street according to the commissioner's map of 1807, which has been generally considered to be equivalent to the U. S. standard, although on very long measurements it has been found a trifle longer, averaging about .017 of a foot, or less than 1/4 of an inch, in 100 feet. The commissioner's map of Morrisannia was laid out by Findley, who, in order to give "good measure," threw into each block enough to make his standard about .4 inches longer in 100 feet than the U. S.

As an illustration of the condition of affairs found in many localities we may take the situation as now existing in King's County, New York. At the beginning of this century the county was entirely an agricultural community, consisting of farming lands, meadows, and wood lands, with a few small villages. No farms had been cut up into lots, nor any regular system of streets laid out or contemplated, except on the Sands and John Jackson estates, situated approximately between Fulton, Tillary and Navy streets, the Navy Yard and the East River, Brooklyn. This tract was laid out in 1788 by Cassimer Th. Gœrck* into blocks of several different lengths and widths; a comparison of several distances would indicate that the standard used bore the relation of about 36 to 36. 134 of the present U. S. standard. In 1805–6 the Hicks estate, in the neighborhood of Fulton Ferry, was cut up into building lots, and in laying out the blocks 200 feet square an extra allowance was given "for good measure" of about 1 foot in 100. The village of Brooklyn, substantially identical with the present First, Second, Fourth and Fifth wards, was incorporated in 1816, and in 1819 the trustees had a map made showing the streets and roads then in existence. Prior to 1834, when the city of Brooklyn was first incorporated, most of the lands included within the old village of Brooklyn, together with several outlying districts covering most of the present Third, Sixth, Tenth and Eleventh wards, part of Red Hook, and the lands adjacent to Clinton and Washington avenues, had been laid out into blocks and lots according to various standards, but for the most part by the "New York" standard. This was determined by Hassler to have the ratio of 36: 36.01545 of the Troughton scale, which was subsequently adopted

* Stiles, *Brooklyn*, I., p. 382.

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as the U. S. standard, and is taken by some surveyors to bear the relation of 36 : 36.0288 of the U. S., or 8 inches longer in 1000 feet, which is equivalent to 36 : 36.0240. The district between Third, Fifth and Atlantic avenues and Douglass street was laid out by this standard, which, in a distance of 2000 feet, gives a surplus at Douglass street of 1 foot and 6 inches, which is deducted from the next block (making the lots on the north side of Degraw street 98 feet and 6 inches deep, instead of 100), in order to make the distance from Atlantic avenue to Degraw street correct according to the U. S. standard.

In 1835, an act of the legislature (ch. 132) was passed appointing commissioners to lay out the City of Brooklyn in a regular system of streets. They devised a plan for the city, adopting such streets as had been previously laid out, as far as possible. Under their direction, John Stoddard laid out and monumented the entire original city of Brooklyn (which comprised the old town of Brooklyn), outside of the first five wards, excepting those tracts which had previously been laid out. He was occupied in the field from 1835 to December 31, 1838. He procured from the U. S. government a yard scale, from which he had ten 5-foot steel bars constructed with which he standarded his chains and measures. It is considered that Stoddard's standard was identical with the United States, and was found to be so by McElroy, who compared the fifty feet of Stoddard's bars with the standard procured for the Town Survey, and found them to agree within a hair-breadth. In the various districts where streets had already been laid out, he generally left them as they were. Many anomalies exist on these tracts; for example, there is a surplus of about four feet in the length of Clinton Avenue, and consequently the sections on the George W. Pine map, which are shown as 100 feet in width, are actually about 100 feet and 1 inch by the U. S. standard; on the Henry L. Clarke tract, in the 22d ward, a surplus of about two inches was found in the blocks, which was thrown into the corner lots; on the John Skillman farm, in the 7th ward, which was laid out from Myrtle Avenue as a basis, there was found a surplus of three or four feet at the northerly end, which was put into the lots of irregular depth fronting on the Wallabout road, and obliterated by the cutting off of these lots on the opening of Flushing Avenue.

The first tract laid out into lots in the Eastern District was the

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original village of Williamsburg, as shown by the maps of Loss, Bridges, and Poppleton, dated 1802–6–9. This covered a portion of the Francis Titus farm near Grand Street ferry. The lots were of somewhat irregular shape, and the standard used seems to bear the relation of about 36 : 36.03 of the U. S. In 1834, and the following years, Daniel Ewen laid out the original chartered village of Williamsburg into streets, according to a system shown on his assessment maps, adopting the streets already laid out on the old Williamsburg tract, the John Miller, Holmes Van Mater, and other farms. He used the New York standard, which has been found, as he used it, to be about 1 inch longer in 100 feet than the U. S. A few years later, the "Additional Bounds" of Williamsburg were laid out by the same standard.

The town of Bushwick was laid out into streets in accordance with the directions of a commission appointed by chapter 296 of the laws of 1852, although several farms, particularly in Greenpoint, had been cut up into blocks and lots before that year, mostly by Ewen and Betts, who used the N. Y., or long standard. The northerly or Greenpoint section of the town was laid out by Morgan Brothers, who used a standard about 1½ inches longer in 100 feet than the U.S.; and the southerly portion by Martin G. Johnson, who used Ewen's Williamsburg standard, 1 inch in 100 feet longer than the U. S. Another ratio, given by a good authority, is for Greenpoint 100 : 100.0983, and for the rest of Bushwick 100 : 100.0775.

A large part of the town of New Lots, now the 26th ward of Brooklyn, was laid out into streets according to a system originated and developed by Martin G. Johnson. He used a standard determined by McElroy to be as 36 : 36.0329 of the U. S., a line given by Johnson as 5450 feet having been found to be 5454.98 of the U. S. standard. This is the relation accepted by most surveyors, although one excellent authority gives it as 36 : 36.0240, which is identical with the New York standard as determined by some surveyors in the older parts of Brooklyn.

In 1869 an act was passed (chapter 670) appointing the supervisors a commission to lay out all the county towns in a system of streets, conforming to the streets of Brooklyn as far as practicable. Under this act, a system of streets and avenues was devised, maps prepared, and the territory surveyed and monumented by Samuel McElroy & Son, who procured a standard from the

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U. S. Coast Survey, which was compared with Stoddard's bars, with the result already mentioned. In the districts where streets had already been laid out, such as parts of Flatbush village, Fort Hamilton village, etc., the Town Survey commission accepted the streets as existing. The exceptional localities present many different varieties of standard. In Fort Hamilton village the standard used was about 1⅛ inches (in one block about 5 inches) in 100 feet longer than the U. S.; and in Parkville it was about 1 inch in 100 feet too long.

For purposes of comparison, we may tabulate some of these varying standards as follows:

	Length of Yd. in U. S. Stand'd Ins.	Length of 100 ft. in U. S. Standard feet and inches.
New York State Standard Yard, as determined by Hassler,	36.01545	100.043 = 100 ft. $\frac{3}{8}$ in.
New York State Standard Yard, corrected for the error of the Troughton scale,	36.01621	100.045 = 100 ft. $\frac{3}{8}$ in.
New York City "down-town" standard,	36.0375	100.1042 = 100 ft. 1¼ in.
" " "up-town" stand., Randall,	36.0061	100.017 = 100 ft. $\frac{1}{16}$ in.
New York Standard as used in Old Brooklyn,	36.0288	100.080 = 100 ft. $\frac{3}{32}$ in.
" " " " " [by another estimate (+8 ins. in 1000 ft.)	36.0240	100.066+ = 100 ft. $\frac{1}{16}$ in.
New York Standard as used in Old Brooklyn, as indicated by the distance from Atlantic Ave. to Douglass St., 2000 ft = 2001 ft. 6 in. U. S.,	36.0270	100.075 = 100 ft. $\frac{9}{32}$ in.
New York Standard as used in Williamsburg by Ewen [+1 in. in 100 ft.]	36.0300	100.083+ = 100 ft. 1 in.
New York Standard as used in Greenpoint by Morgan Bros. [+1½ in. in 100 ft.]	36.045	100.125 = 100 ft. 1½ in.
New York Standard as used in Greenpoint by Morgan Bros., by another estimate,	36.0359	100.0983 = 100 ft. 1 $\frac{3}{16}$ in.
New York Standard as used in Bushwick by Johnson [2d estimate mentioned],	36.0269	100.0775 = 100 ft. $\frac{1}{16}$ in.
New York Standard as used in New Lotts by Johnson, [5450 = 5454.98 U. S.]	36.0329	100.0914 = 100 ft. 1 $\frac{3}{32}$ in.
New York Standard as used in New Lotts by Johnson, by another estimate,	36.0240	100.066+ = 100 ft. $\frac{1}{16}$ in.

It is thus perfectly apparent that there is an entire absence of uniformity, and that if the measurements of land in Kings county were made strictly according to the statutory standard great discrepancies would be disclosed, and endless litigation result therefrom. From the use of various standards, and the errors of those surveyors who originally laid out the farms into blocks and lots, the utmost confusion has apparently arisen, so that it has come to

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be the practice of the best surveyors, not only in Brooklyn and Kings county, but also in New York and other places, to consider each block as a standard for itself, and taking its length at the regular "statutory" distance, that is, as defined by the official maps, no matter what it may actually measure, to make their surveys accordingly and distribute the surplus (or deficiency, which is rarely found) *pro rata* as far as practicable, sometimes, however, modifying their distribution according to the lines of actual possession, as indicated by buildings of several years' standing.

It remains only to consider the legality of this custom. It is clear that this method is the only equitable solution of the difficulty, and on the other hand we have the statute which prescribes the United States standard as the only legal standard to be used in the State, and the only one permissible in the decision of controverted questions of measurement brought before the courts. The practical consideration of the question in individual cases will necessitate, to a greater or lesser extent, the examination of the title to the land on the block involved. If the original owner of the block caused a map of his property to be made, and filed in the public record office, showing the block laid out into lots of which the aggregate width equalled the official length of the block and sold his lots according to this map he would be estopped from setting up any claim to any surplus that might be actually found to exist in the total length of the block; and the same might probably be said of any owner who sold according to any actual map or plan, although not filed, which recognized the official length in contradistinction to the actual. And all subsequent grantors using the description by lot numbers would be equally estopped, it being the undoubted intention in referring to the map to designate a parcel of land of proportional size to the whole block which the map indicated, irrespective of the actual dimensions.

A more serious difficulty would arise when a grantor who had purchased his land by a description referring to the map, conveys by a new description omitting any mention of the map. Must we then apply the official legal standard, or shall we adhere to the local standard of the particular block? Regarding this question the case of Meyer *vs.* Bond, 51 Hun., 291, is directly in point. This was a suit for specific performance of a contract of sale and purchase of a lot on the southerly side of Eighty-first street in New York city, described as beginning 125 feet east of Third

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avenue, and being 25 feet wide. The vendee refused to complete his purchase, contending, that, as a survey showed that the lot was 127 feet and 1 inch east of Third avenue, and 25 feet and 5 inches wide, the vendor could not carry out his contract. This discrepancy arose from the fact that on the map of the Harlem Commons, on which this property was designated as lot number 34, there was an error in calling the blocks between Second and Third avenues 600 feet, when, as a matter of fact, they were actually 610 feet. The testimony of Mr. Ewen, a surveyor, was produced, showing "that at different times the owners, to adjust the surplus of 10 feet in the length of the block, had directed him to locate them by making a distribution of them *pro rata* over the entire front of the block, which gave a surplus of 5 inches to every 25 feet;" and furthermore that many of the owners had acquiesced in this distribution either by erecting buildings on the readjusted lots or by conveying their property by properly corrected descriptions. In view of these facts the court decided that the discrepancy in the distances was no objection to the title, no damage resulting thereby, as "each owner is protected by the readjustment which controls and overcomes the original error, and subjects it to natural distances and establishes monuments."

We are thus brought to the conclusion that where there has been actual possession for the statutory period of limitation, or acquiescence by owners in the distribution of the surplus, it is binding on all, although the distances given in the conveyances do not accurately define the locus of the premises according to the statutory standard.

When we come to consider the cases of conveyances of property where no map was originally used, serious doubt may arise as to whether we are justified in making a *pro rata* distribution of a surplus. A grantor owning a whole block, by conveying from each end, using ordinary descriptions by distances, and not referring to a map, would undoubtedly retain title to the surplus land left where his conveyances did not meet. He might lose this, however, by the running of adverse possession against him, and when the property came to be built up the walls of the houses would constitute established monuments which would govern (Muhlker *vs.* Rupport, 124 N. Y., 627). But in the case of vacant unimproved property this might raise a serious question.

There is only one other thing to be said, which is, that the acts

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of the various commissions, appointed to lay out streets in cities, might, under some views, be considered conclusive and their designation of a certain block as of a certain length final. The act of 1835 (chap. 132) for laying out the first city of Brooklyn (outside of the first five wards) distinctly prescribes that "the maps plans and surveys of the said commissioners, so to be made by them, or any two (2) of them as aforesaid, shall be final and conclusive, as well in respect to the said mayor and common council as in respect to the owners and occupants of the lands, tenements and hereditaments within the said sixth, seventh, eighth and ninth wards of the said city, and in respect to all other persons whomsoever." Monuments are placed to designate the streets shown on these commissioners' maps, and it might possibly be held that grantors in bounding on these streets, by implication, referred to these monuments, and thereby accepted them as defining the distances which the map indicates.

It would seem that in view of the difficulties in the case, and the eminent fairness of this custom of surveyors, that it would be upheld by the courts, particularly in cases where no damage results to any one, as is almost invariably the fact; but, from the paucity of adjudicated cases in the higher courts the question remains an unsettled one, which must be considered in each individual case in the light of the particular circumstances entering into it.

AN IMPROVED METHOD FOR THE SEPARATION QUALITATIVELY, OF Hg, Pb, Cu, Cd, Bi, As, Sb, AND Sn FROM THEIR MIXED SULPHIDES.

By ALEXANDER R. CUSHMAN, Ph.D.

The necessity for a modification of the ordinary scheme in use for the qualitative analysis of the fifth and sixth groups, according to Fresenius's arrangement of the metals, has led me to propose the following as very satisfactory in its results. Yellow ammonium sulphide $(NH_4)_2S_x$, converts the mixed sulphides of mercury and tin into a compound containing both of these metals, and which is readily soluble in water. The digestion with this reagent, which is necessary in the usual method of separation of the fifth and sixth groups, obviously introduces a complication which I have sought to remove.

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In the method proposed, the usual precipitation of silver, mercurous salts and lead by means of hydrochloric acid is assumed to have been made, and the filtrate, now acid, is treated with H_2S gas in order to precipitate the sulphides of the fifth and sixth groups. The mixed sulphides are now warmed with $(NH_4)_2S_x$, and after digestion, are filtered through a *dry* filter. The residue is then washed with a 10 per cent. solution of NH_4NO_3, which removes the excess of $(NH_4)_2S_x$, but is without effect upon the soluble compound of sulphides of tin and mercury contained in the residue. This residue is now treated with moderately dilute HNO_3, with the application of a gentle heat, filtered and washed. The metals of the fifth group, with the exception of Hg, will be found in the filtrate, while in the residue there are contained HgS and metastannic acid.

This residue is finally treated with aqua regia to dissolve the HgS, and the remaining metastannic acid may be filtered off and tested on charcoal by moistening with cobalt nitrate and ignition in the outer blowpipe flame. The appearance of the characteristic bluish-green color proves tin. Or, the metastannic acid may be reduced to metallic tin by means of zinc and platinum, then dissolved in HCl and tested with $HgCl_2$.

A portion of the tin will also be found in the solution of the sixth group sulphides in $(NH_4)_2S_x$, and is there to be separated in the usual manner.

SCHEME FOR THE SEPARATION OF Al, Cr, Ti, Co, Ni, Zn, Mn, Fe.

By J. S. C. WELLS, Ph.D.

In the method commonly used for the separation of the above metals by means of potassium or sodium hydrates, the presence of zinc or chromium in the same solution very greatly complicates the analysis, owing to the fact that these substances precipitate each other in alkaline solution. The scheme given below avoids this difficulty and is rapid and accurate.

To the solution of the metals add NH_4Cl in moderate quantity, then NH_4OH until solution becomes slightly alkaline, and finally $(NH_4)_2S$ until solution smells distinctly of that reagent; stir well and heat gently for some time, filter and wash precipitate.

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Filtrate 1°.	Precipitate 1ª.
Contains the alkalies and alkaline earths.	Treat with cold dilute HCl (sp. gr 1.02) in moderate excess; filter and wash residue thoroughly.

Residue. (CoS. and NiS.)	Filtrate 2°.
Test in borax bead, Blue bead = Co. Brown bead = Ni. If Co is found to be present, treat the residue of sulphide as follows: Place in a small evaporating dish, add aqua regia and boil, evaporating nearly to dryness; dilute with a little water; filter if necessary; nearly neutralize the solution with KOH; add KCy in moderate excess; make strongly alkaline with KOH, and add Br, and warm, taking care to keep solution strongly alkaline. Filter, and wash precipitate thoroughly with boiling water.	Evaporate nearly to dryness to expel H_2S and the excess of HCl; dilute with a little water; filter, if necessary, from any separated sulphur*; add strong solution of KOH in considerable excess, and then a few drops of bromine; (it is better to use pure bromine rather than bromine water); heat gently for a few minutes, filter, and wash precipitate with boiling water.

Filtrate.	Ppt. $(Ni_2(OH)_6$. Black.	Ppt.3
Cobalt may be determined in this solution, if necessary, by acidifying with HNO_3, and then adding $(Hg)_2(NO_3)_2$; filter and ignite the precipitate, and test residue in borax bead; blue = Co.	Test in borax bead — brown bead = Ni.	Test a portion in Na_2CO_3; bead in oxidizing flame, green bead = Mn. Dissolve some of the precipitate in HCl; test a portion of this with NH_4CyS for iron. Red color = Fe^{IV}; test remainder of solution with Zn or Sn — violet color = Ti.

Filtrate 3°.

Divide solution into three parts.

1°.	2°.	3°.
Pass H_2S gas into the solution (not to saturation) — a white precipitate, insoluble in KOH = ZnS.	Acidify with HCl, then make very faintly alkaline with NH_4OH — a white flocculent precipitate = $Al_2(OH)_6$.	Acidify with acetic acid and add a few drops of plumbic acetate — yellow precipitate = $PbCrO_4$ = Cr.

* If the color of the solution at this point does not indicate the presence of chromium, the treatment with bromine may be omitted, but in this case iron, if present, must be oxidized by boiling the solution with a little HNO_3 before the addition of the KOH.

A solution containing one part of chromium in ten thousand of water shows a distinct bluish green color, consequently a colorless solution could not contain more than a trace of that metal.

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A general view of the reactions taking place in the scheme just given is shown in the following table, assuming all the metals to be present as chlorides:

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* Blood-red color. † Violet color.

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THE ASSAY OF LOW-GRADE IMPURE TIN ORE.

By ROBERT PEELE, JR.

THE determination of tin by fire assay is a simple and fairly accurate process, provided the ore is pure or nearly so; that is, when the bulk of the material is oxide of tin, with only a small percentage of gangue. But with low-grade ores no direct method will serve. It is well known that a crucible charge, with ore containing only a few per cent. of tin, will often give no button at all. In general, it may be said that the fire assay on duplicate samples of ores carrying as high as even 15 or 20 per cent. of tin, with a gangue composed of quartz, oxide of iron and other impurities, may give widely conflicting results. Even with pure silica tin forms compounds which go into the slag.

It is evident, then, that upon the proper preparation of the sample will depend largely the accuracy of the assay.

Something over a year ago the writer had occasion to assay a large number of samples of tin ore, and, with the help of the text-books, and a number of failures at first, arrived at the following method of procedure. There is nothing novel in any part of it, but it is thought that a detailed description of the manipulation of poor tin ores will not be amiss.

In the particular case referred to the composition of the ores was the following:

1. Gray cassiterite, intimately associated with quartz and oxide of iron, with, possibly, other impurities in small amounts. Percentage of metallic tin, from one-half of 1 per cent. to 15 per cent.

2. Iron pyrites, carrying from 2 to 5 per cent. metallic tin. This was roasted and treated the same as the oxidized ores.

The preparation of the samples is as follows:

Take samples of from 50 to 200 grammes (depending upon the probable content of tin), and pass through a 60-mesh sieve. Wash very carefully in a small gold pan or in a "horn spoon," merely to float off the lighter and finer particles of gangue and iron oxide. Do not attempt to concentrate down the sands, or tin will be lost.

Dry the residue, which may weigh one-half or two-thirds of the

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original sample, and then grind again in a porcelain mortar as fine as possible—say, to 100 mesh—in order to liberate all the tin oxide from the gangue. Treat the finely-ground sample in a flask or casserole with a mixture of one-fourth nitric and three-fourths hydrochloric acid. Gently heat with frequent stirring, and then evaporate down until the mixture thickens and begins to show signs of sticking to the bottom of the vessel. Fill with water, running off the fine disintegrated portion of the ore into a beaker. Allow the contents of the beaker to settle a few moments, and decant the muddy water carefully, so as not to lose any of the fine tin possibly remaining in the bottom. Add the residue from the beaker to the residue from the acids, and treat again with acid as before. This may have to be repeated a third or even a fourth time.

Finally, after the last washing in the casserole, nothing will remain except tin oxide (whitish or grayish in color), with nearly pure white silica.

Take this residue and wash very carefully to separate the silica. This is so much lighter than the tin that it may be removed without difficulty. In doing it the writer used a small wooden batea, or conical dish, with a well-smoothed surface.

By collecting the material in the point of the cone with a little water, and giving the batea a gentle rotary motion, the silica gathers on top of the tin oxide. Then, by a slight movement of the batea, the silica is thrown off to one side, and a part, at a safe distance from the tin, is washed from the batea. This is repeated until the tin oxide is nearly pure.

With careful handling, loss of any appreciable amount of tin in this washing is easily avoided, on account of the difference in color and specific gravity.

Dry the residue, which is now ready for the fire assay. For nearly pure cassiterite potassium cyanide makes an excellent flux.

Put a few grammes of powdered cyanide in the bottom of a small French crucible that will go into the muffle, and make up the charge by mixing the ore with three or four times its own weight of cyanide, covering with salt. The amount of tin oxide in the charge will, of course, depend upon the richness of the original ore; from 5 to 10 grammes are sufficient.

Fuse in the muffle with a hot fire, 10 to 15 minutes, until there is no ebullition, and tap the crucible on withdrawing it, to settle

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and collect the button. After cooling, break the crucible, and put the whole into a beaker of warm water. In 15 or 20 minutes all the cyanide slag will be dissolved out, and any small scattered buttons of tin are thus recovered. Remove from the beaker the pieces of the crucible, and wash off by decantation the flocculent matter remaining in suspension, leaving the tin button to be dried and weighed.

The process is rather long and tedious, but it will be found satisfactory, as it reduces the chances of loss, which would result from a closer washing of the ore at the beginning of the preparation.

It also possesses the advantage of being applicable to the poorest as well as the richest ores.

With some ores, consisting of nothing but quartz and cassiterite, the preliminary concentration by washing may be carried far enough to yield a product sufficiently pure to assay directly without treatment by the acids.

But if the ore is very poor, a close washing will be attended by considerable loss, and hence the advantage of using the acids in nearly every case. If iron and other impurities are present, the first washing should be limited as indicated in the description.

PRESENT CONDITION OF THE MECHANICAL PREPARATION OF ORES IN SAXONY, HARTZ, AND RHENISH PRUSSIA.*

By M. MAURICE BELLOM, ENGINEER IN THE FRENCH GOVERNMENT MINING CORPS.

The study of the mechanical preparation of ores in Saxony, Hartz, and Rhenish Prussia, is not, as would be supposed at first sight, hetrogeneous and composed of three distinct parts, brought together solely by the unity of the subject. On the contrary, it consists of a whole, the three elements of which mutually complement each other. Saxony possesses, in fact, relatively crude plants only, but the methods practiced there are studied with minute care down to the smallest details, and no change is intro-

* *Annales des Mines*, 1891, vol. xx., p. 1.

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duced without having been made previously the subject of careful and repeated experiments, the results of which tend to make good the crudity of the apparatus by perfection of treatment. The Hartz, although not furnishing such carefully digested schemes of treatment, is nevertheless characterized by the endeavor, which is pursued with perseverance, and not without success, to make good the increasing poverty of the slimes obtained in the course of mechanical preparation by more perfect concentration. Rhenish Prussia, where the series of operations is far from being as elaborate as in the preceding regions, contains dressing-works of a size and convenience nowhere met with either in Hartz or Saxony.

There is, then, in this subject, the elements of which complement each other, a real unity of interest, which seems to justify the study I have seen fit to give it in the course of a tour of inspection in 1889.

The present paper consists of two parts. The first is given to the general study of the successive operations of treatment accompanied by a description of the most recent forms of apparatus and their application under different conditions in practice. The general arrangement of the dressing-works will likewise be made the subject of special discussion.

The second part is devoted to the description of establishments which seem to merit a special mention, by reason of their form of treatment or equipment.

This order is in reality the reverse of that which should be followed in the study of the dressing-works on the spot, but it is the one which best lends itself to a description of such complex processes, for which a logical exposition of the operations presents an interest far superior to the chronological order in which the data have been collected.

I.—Hand Dressing.

a. Method of Treatment.—The operation of hand dressing, which immediately follows the separation of coarse and fine ore by screens, would seem at first sight too simple to require anything but a casual notice. Such a judgment would be singularly erroneous. And, in fact, in a country like Germany, where habits of discipline secure on the part of the workman an attention and

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care difficult to realize without having seen, hand-labor produces remarkably perfect results.

Indeed, the Saxon engineers at one time tried to substitute for it breaking in a mechanical crusher, but quickly returned to the use of hand labor after having, according to the traditions of precision which is the essential characteristic of their method of treatment, verified by statistics the practical results of the experiments which they had made.

These are summed up in the following table:

Products.	Using a jaw-crusher, followed by picking. a (parts in 100.)	Practice of breaking by hand. b (parts in 100.)	Difference. $b - a$ (parts in 100.)
Galena	0.0024	0.330	+ 0.3276
Ore for the rolls	29.836	22.300	— 7 536
Ore for cobbing	27.976	9.240	— 18 736
Ore for the stamps	25.268	19.580	— 5.688
Copper pyrites	1.488	4 560	+ 3.072
Iron pyrites	3.869	0.700	— 3 169
Mispickel	0.496	0.490	— 0.006
Blende	0.0446	0.100	+ 0.0554
Waste	11.019	42.680	+ 31.661

It is seen that picking which immediately follows mechanical crushing can separate only 11.019 parts in 100 of waste from the total mass coming from the mine, whereas the practice of breaking by hand takes out as much as 42.680 parts in 100. The immediate result of this difference was to throw an excess of 31.661 parts in 100 of waste products into the series of operations of mechanical preparation. On the other hand, the separation of galena became nearly useless after passing through the crusher, whereas that of blende, the presence of which singularly complicated the treatment, was reduced in the neighborhood of one-half. So that instead of sending to mechanical treatment 51.12 parts in 100 of the total mass extracted from the mine, in the case of a jaw crusher 83.08 parts in 100 of this same mass must be so treated; in other words, an excess of 31.96 parts in 100. The expenses naturally differ in proportion to these differences in product; the total cost per cubic meter of ore from cobbing, which

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does not exceed 8.51 f. in the case of hand labor, goes as high as 14.10 f. when the jaw crusher is employed, which constitutes an increase of 39.73 f. p. 100. At the same time the quality of the product was far from bettered, and its value was diminished to such a degree that the rough product of a cubic meter of ore from the cobbing dropped from 86.40 f. to 72.18 f., reducing the net profit per cubic meter from 75.39 f. to 57.06 f. These results naturally led to the abandonment of mechanical crushing.

The hand dressing done at the surface is at times preceded by a rough picking at the bottom of the mine, which presents some real advantages notwithstanding the unfavorable conditions which surround it. These advantages have been verified in the Saxon dressing-works at Himmelsfürst, where it has been found that the proportion of rich ore separated by hand at the surface has increased notably in the course of several years, a result which could be attributed only to the great care with which the workmen at the bottom picked the ore, for the composition of the ore has not varied.

Without devoting themselves to such precise experiments as the Saxon engineers, the directors of the Rhenish works have been guided by the same principles, especially in the mine at Friedrichssegen, the washing house of which will be described in detail in the second part of this paper. The subterranean working has been so organized as to allow the picking to be carried on upon a large scale. Here each stope is provided with two chutes, by which the mined product is carried to the gangway; a screen with apertures two inches square is placed at the upper end of one of these chutes and the refuse of the screen is thrown down the other, together with any large pieces separated. Fragments containing only one of the four elements (galena, blende, spathic iron-ore, and copper-ore) which constitute the filling of the vein are also separated and so a first classification is obtained, the satisfactory execution of which is assured by a premium allowed to these workmen. These premiums run as high as .65 f. per car of spathic ore, and 1.25 f. per car of blende, galena or copper ore.

Hand dressing done at the surface comprises three essential operations, the development of which differ according to the practice of the works; these operations are: 1. Spalling. 2. Cobbing. 3. Hand picking.

1. Spalling consists in breaking, by aid of heavy hammers, the

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larger pieces previously separated, by means of a screen, from the mass of the output. It can be dispensed with in the case of poor and relatively simple ores. In the Hartz proper certain ores require a very elaborate spalling.

Thus the presence of blende at Lauthental has led to the adoption of a spalling so minute as to be considered a preliminary cobbing. On the other hand, the study of the forms of treatment of certain complex ores, such as that at Churprinz (Saxony), seem to furnish cases in which spalling does not enter at all. But the suppression of this operation is more apparent than real. It is really only the consequence of a considerable extension here given to the picking at the bottom. Elsewhere, as at Himmelsfürst (Saxony), spalling is found to be included in the cobbing whose province is thus considerably extended.

2. Cobbing is nothing more than a very careful breaking. It throws out of the mechanical process proper a mass of ore which in the works of Gesegnete Bergmanns Hoffnung (Saxony), goes as high as 25 parts in 100. The success of the operation is, moreover, intimately connected with the mode of determination and with the number of classes it is necessary to make. The best mode for determining these classes is that which depends upon exact chemical analyses combined with mineralogical characteristics so simple that the cobber may easily recognize the pieces which he must separate. From this double point of view, the works at Himmelfahrt (Saxony), may be cited as a model. The number of classes must not be exaggerated; the tendency should be to constantly reduce them. Thus in the practice at Ems, where, twenty years ago, twenty-four species of product were distinguished, they are at present satisfied with sixteen categories, the minimum number which the complexity of the Ems ore will allow. A practice to be recommended in the work of cobbing is to divide it into several analogous but distinct operations, the first of which, applied to the less pure ore, is carried on by less experienced workmen, while the last, to which the sorted ore is sent, is intrusted to the most experienced cobbers. This system has been applied at Friedrichssegen. A first cobbing at that place gives:

1. Finished products.
2. Intermediate products to be submitted to a second cobbing.
3. Intermediate products to be crushed in jaw-crusher. The

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crushed intermediate products are submitted in turn to a new cobbing, which gives:

1. Finished products.
2. Intermediate products to be submitted to another cobbing.

The products of the second class obtained in the two preceding operations are submitted to a careful cobbing at the hands of very skilful workmen and in places set apart for this work.

3. Hand picking is a separation by hand without breaking the pieces, and is applied in Saxony only to the products coming from cleansing drums. Extended in the Hartz to products already treated in intermittent jigs, it has lately been applied to the material from continuous jigs and also from filtering jigs, these last being used, as we shall see later on, for ore coarser than fourteen millimetres at Steinenbrück. Here is, then, a progressive introduction to hand-work in the operation of mechanical jigging, an introduction so much the more interesting as pointing out that the substitution of continuous and filtering jigs for the old intermittent jigs seems to show a growing tendency to the use of machines.

These three elements of spalling, cobbing, and hand picking admit of association in different ways and combinations between themselves with a facility which is one of their principal advantages. The passing from one to the other of these assures success in the treatment of complex ores, when, as at Himmelfahrt, these processes are judiciously combined in a series.

(*b*) *Apparatus for Hand Dressing.*—There is but little to be said of the appliances used in the execution of this first phase of treatment.

The separation of coarse and fine at the entrance of the ore into the works is effected upon a screen which is usually formed of parallel, inclined bars, but which sometimes, on the contrary, as at Ems, is horizontal and pierced by hexagonal holes. This arrangement gives a more precise sorting, but demands more labor, for to assure the passage of the fine through the holes, the material upon the screen must be stirred with a stick.

Spalling is done near the screen in simple sheds.

Cobbing is done in workshops, presenting in their arrangement a symmetry suitable to the uses to which they are applied. The cobbing shop at Ems, for example, is composed of parallel rectangular chambers (see Figs. 1 *a* and 1 *b*) dug in the earth. The cars which carry the ore enter on the rails *rr* and are unloaded

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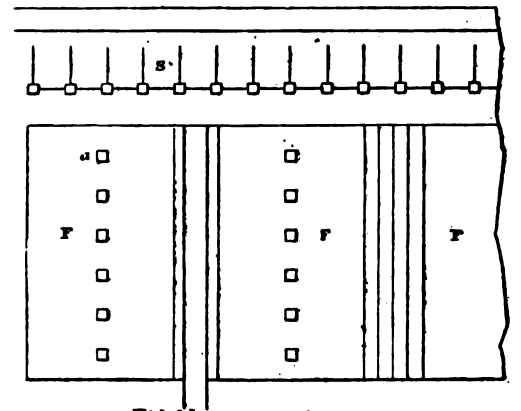
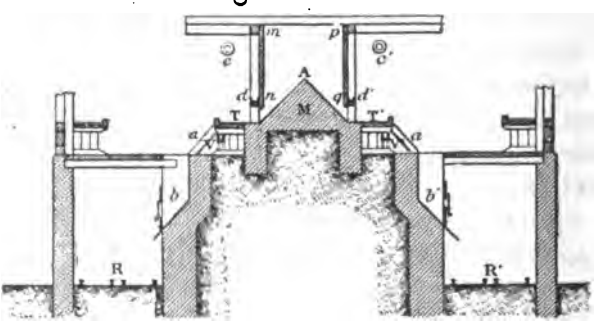
in the chambers F F′, where the cobbers are seated upon the benches *a*; between two consecutive chambers F F′ rise small shelves, which receive the boxes containing the cobbed ore. These

Fig. 1 a (Scale 1/200)



boxes, when full, are emptied into wheelbarrows, in which the ore is taken to the stalls S, from which the rails P P take the cars, used to transport the products deposited in these stalls, to the mechanical preparation.

Fig. 2 (Scale 1/160)



Hand picking is carried on under different conditions, according to the operation which it follows. If we have to deal with picking which occupies a place at the beginning of the treatment, and which

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consequently deals with considerable quantities of material, recourse must be had to the use of either revolving tables or even of spacious shops similar to those at Clausthal, which will be described later. If, on the contrary, we have the picking of jigged copper-ore, small, wooden, inclined stands suffice, to which the small quantities to be handled are carried on a shovel; this last solution is seen at Laurenburg.

The shop at Clausthal (Fig. 2) which, by reason of the accidental character of the ground, was obliged to be placed below those from which it received the products, carries upon the beams of its frame-work the continuation of the rails which transport the cars charged with ore to be picked. These cars can thus be unloaded upon the wall of masonry M, having at the top a horizontal ridge, which separates the material upon two inclined planes. The rails $r' r'$ are used to carry off the empty cars. These planes constitute the bottom of a sort of hopper, limited elsewhere by the vertical walls $m n p q$, the lower part of which is separated from the picking tables T T′ by a groove into which the ore is allowed to fall. The arrival of the products upon the tables T T′ is finally effected by pickers armed with sticks, which these workmen also use to push the waste into the conduits $a a'$, which send it to the inclined planes $b b'$. A vertical damper empties these inclined planes into cars running on the rails R R′, which have the same level as the workshop where the picked material is treated. Benches $d d'$ take the boxes of picked ore as soon as the other products are emptied down the chutes $b b'$. The water necessary for the washing of the fragments to be picked is provided by the cast-iron conduits $c c'$; they drain the picking tables by the trenches V V′.

An improvement recently applied to the work of picking at Freidrichssegen consists in the substitution of hot for cold water for the washing intended to cleanse the surfaces of the fragments to be picked. The use of this hot water, which is furnished by the condensation of the steam from the motive machinery, assures for the pickers, notably in cold weather, an advantage which may easily be secured whenever steam-power is used.

II.—Mechanical Crushing.

(*a*) *Method of Treatment.*—Mechanical crushing is done either with crushers, mills, stamps, or rolls.

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1. *Crushers.*—Either the products coming from spalling, as at Steinenbrück and Weiss, or products to be subsequently hand picked, as at Churprinz, are sent to the crusher. In the first case the crusher prepares the ore for the rolls; in the second it prepares them for sorting by hand. In certain works preliminary breaking does not exist, either, as at Ems and Himmelfahrt on account of the excessive complexity of the ore, or, as at the works of Gesegnete Bergmanns Hoffnung, by reason of the natural concentration of the rich parts which permit the separation of the ore, by spalling, into two classes; one very rich which is sorted by hand, and the other very poor which must be disintegrated by the stamps. The works in Hartz furnish a complete gradation in the use of crushers, from the works at Clausthal, where mechanical crushing supplants breaking by hand, to the shop at Schulenberg where crushers are not used at all, and the practice of Lautenthal, which serves as a mean between these two extremes, and is an example of a combination of the use of crushers and manual labor. Lastly, on the banks of the Rhine, the crusher is only used for relatively simple ore requiring a less careful cobbing.

2. *Schranz Crusher.*—This machine occupies a place between jaw-crushers and rolls. It resembles the first in its form and the second in the fineness of the grains it furnishes and in the facility with which it may be regulated. This crusher, which is only used at Laurenburg, will be studied later.

3. *Mills.*—I will not speak of the old style Saxon mills, but will limit myself to the Schranz mill, also used at Laurenburg, where it has supplanted the stamps. It is especially used for ore of a coarseness of 8 millimetres and below and also for crushing intermediate products. A detailed description of it will be given later on.

4. *Stamps.*—Stamps, which are still very much used in Saxony, and even to the exclusion of all other crushing apparatus (as for example, at the works of Gesegnete Bergmanns Hoffnung), tend to disappear on the banks of the Rhine. If the constitution of the sand at Knottes, which is washed at Mechernich, renders the use of these machines indispensable there, the stamps for mechanical preparations at Ems have not been used for some time; and in the recently built works at Weiss, not a single upright stamp is to be found. Elsewhere they have given place either to

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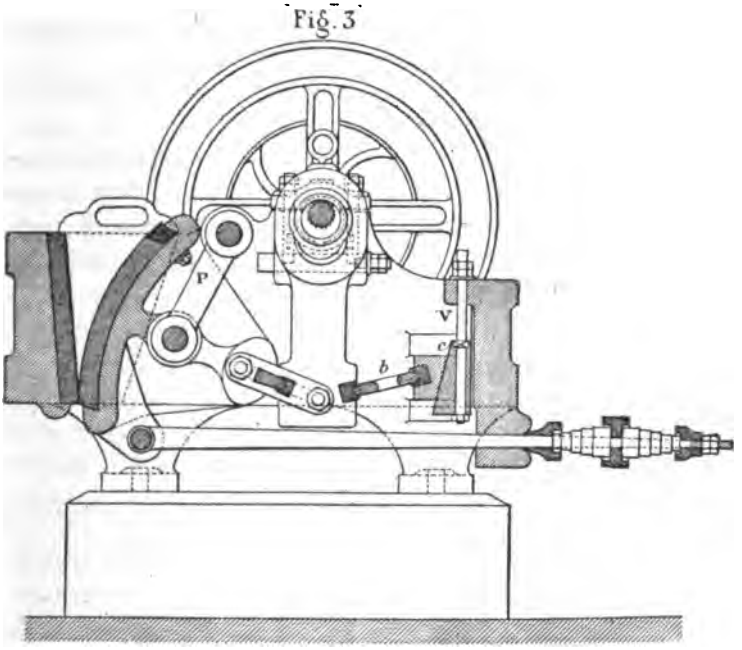
mills, as at Laurenburg, or to rolls as at Steinenbrück. I will not dwell upon the well-known qualities of stamp as a crusher, nor upon its inconveniences from the point of view of the water it consumes and the great noise which it produces. Suffice it to say that the complete suppression of stamps does not appear to be recommended any more than their exclusive use, and the simultaneous use of stamps and rolls, of which the Hartz offers a happy combination, seems to be a solution which conforms better to the diversity in the nature of ores which a terminology already old,

Fig. 3



characterizing the functions of the two principal kinds of crushers, has distinguished as *pocherz* and *walzerz*, ore for the stamps and ore for the rolls.

5. *Rolls.*—Rolls, which (with the exception of Laurenburg, where the Schranz crusher has in a measure, replaced them), are in favor on the banks of the Rhine, are not, as yet, appreciated so much in Saxony or the Hartz. The engineers of Rhenish Prussia boast the precision and ease with which a required degree of crushing may be obtained from rolls without producing as much dust as with the stamps, and although recognizing that these last are nec-

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essary to the pulverization of an ore where the rich parts are disseminated in the mass; in support of their preferences, stress must be laid on the inadvisability of employing stamps for the richer products in which the degree of concentration of the mineral, properly speaking, is higher.

(*b*) *Apparatus.*—After having defined the province of each type of crusher, the only two machines which are new in character may be described; that is to say, the Schranz crusher and the Schranz mill.

1. *The Schranz Breaker.*—The Schranz crusher is a jaw-crusher in which the movable jaw is given a simultaneous movement of rolling and sliding against the fixed jaw.

Fig. 3 shows the nature of this apparatus to which the following details of construction should be added:

The two jaws are made of cast steel; the distance between them is regulated at will by means of a vertical screw V which moves upon a wedge C. The short crank *b* has been cast with such a section that it will break before the other parts if too hard a substance should be engaged between the jaws.

The following table gives the details of the various sizes of the breaker.

	I.	II.	III.	IV.	V.
Available surface of jaws (millimeters)	200 x 150	300 x 200	400 x 250	500 x 300	600 x 350
No. of revolutions of driving pulley per minute	250	250	250	250	250
Diameter of driving pulley (millimeters)	400	500	650	750	1000
Width of do.	100	125	150	160	180
Space occupied by the breaker. Length	1050	1450	1650	1800	1950
Breadth	900	1150	1400	1700	2000
Height to top of fly-wheel	900	1150	1350	1550	1650
Weight of the machine (kilogrammes)	800	2500	4500	6500	9000
Weight of a pair of jaws (kilogrammes)	100	200	300	400	600
Motive force in horse power	1–2	3–4	5–6	8–10	10–12
Quantity of ore crushed per hour	600–1000	1500–2000	2000–3000	3000–4000	4000–5000

The advantage of this machine consists in the fineness of product it furnishes (8 millimeters), which need not be sent to roughing rolls, to which the product of the American crusher

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must pass. The breaker fulfils the office of this last machine, thanks to the acute angle formed by the jaws. These can consequently seize and crush pieces whose size do not allow of their being engaged between the surfaces of rolls, the angle of which can not be reduced beyond a certain limit without giving to the diameter an exaggerated size. Thus at Laurenburg they are satisfied to use a breaker crushing to 8 millimeters followed by a single pair of rolls, which at Steinenbrück under analogous conditions they have to use three pairs of rolls after an ordinary crusher which only breaks to 30 millimeters.

Schranz Mill.—The Schranz mill (Figs. 4 and 5) is composed of three truncated cones, *x*, *y*, *z*, and an annular plate *a*. This plate is fixed by bolts to a disk D, keyed into a socket A in the interior of which passes a fixed axis I. The socket A itself carries a conical wheel R geared with the wheel R′ which is keyed to the shaft B. The rotation of D determines by friction that of the truncated cones which turn each about X a fixed axis in space. By properly determining the pitch of these truncated cones whose common vertex is in the vertical axis I, a crushing of the materials is obtained by simple rolling which diminishes the production of dust.

The plate A, and the disk D, are cast-iron. The latter, which is 275 millimeters in width by 50 in thickness and 1000 millimeters in diameter, has an outside inclination of 10 in the 100. The relation of diameters in the two conical-geared wheels is 1 to 4. The disk D, makes 12½ revolutions per minute. The truncated cones, the bases of which are 475 and 750 millimeters in diameter, are each composed of a core to which is bolted a conical-cast envelope 55 millimeters thick and 275 millimeters long on the generating line. These envelopes are very easily replaced by reason of their form and their mode of attachment. The axes of these truncated cones are fixed on one side by the jointed bolt H to the socket A′ which surrounds the upper part of the axis I, and on the other they rest inside the cast standards K. The upper part, *m n*, of each of these standards is composed of two halves united by bolts, the separation of which allows the removal of the truncated cones when the bolt H has been detached from the socket A′. This last is suspended from the screws V, the adjustment of which combined with that of the rubber springs, P, allows of separating or bringing together the truncated cones *x y z* and the plate, and thus modifying the coarseness of the particles obtained.

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Fig. 4 (Scale 1/40)

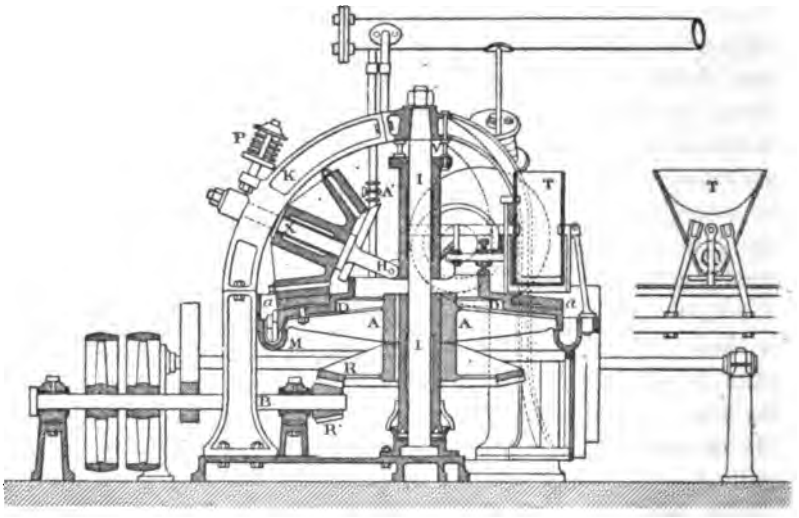
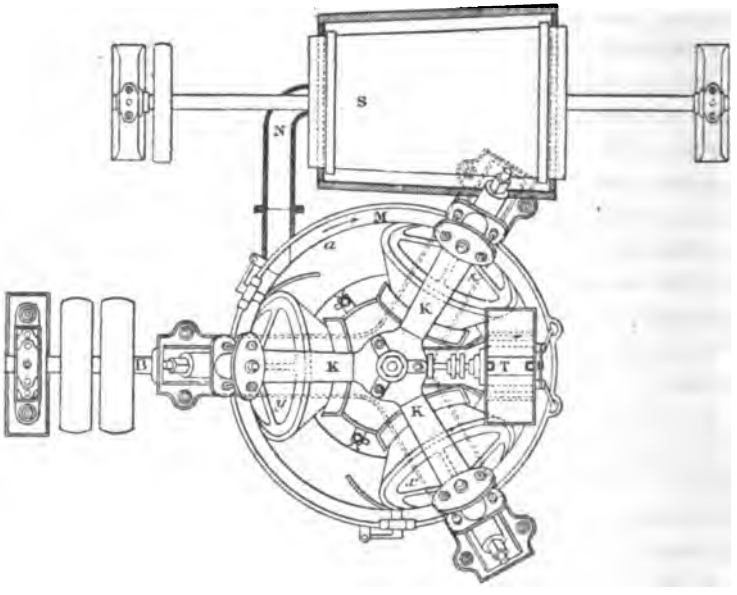


Fig. 5 (Scale 1/40)



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The distribution of the ore to be crushed is determined by means of the hopper T, which is given an alternating movement rapid enough to feed with perfect regularity the slowly-moving plate. If the rotation of the latter is in the direction of the arrows, the products pass under the truncated cone *x*, then under the cone *y*, and finally under the cone *z*. The apparatus is so regulated that the distance of each truncated cone from the plate is minimum for the cone *z*, maximum for the cone *x* and an intermediate value between these two limits for the cone *y*. The most friable grains are in this way the least strongly compressed. A jet of water placed behind each cone detaches from it the particles which adhere to it; a final jet of water washes the crushed ore from the plate into a conduit M, which encircles the plate, and carries the products into the duct N, emptying into the three-millimeter trommel S. The refuse of this is again crushed.

By turning at the rate of 12½ revolutions a minute this apparatus is capable of passing per hour 1460 kilogrammes of product of a coarseness of 3–8 millimeters as it comes from the jigs. 97 litres of water is consumed by the mill per minute, and 20 litres by the trommel. The mill requires a motive force of 3–3.5 horse-power.

A series of experiments have been made at Laurenburg with this apparatus which is employed there with success.

In the first series a comparison was made between the work of the Schranz mill and that of a battery of 15 stamps. Each stamp weighs 160 kilogrammes and gives 60 blows per minute, with a drop of 100 millimeters. Equal weights (calculated with an allowance made for water), were made to pass through each apparatus, the grains varying from 5–8 millimeters as they come from the jigs. The pulverized ore was discharged by each of these two crushers, with the water necessary to carry off the products into a trough 7 meters long by 0.24 meters in width, which is divided into compartments by partitions. The sand deposited was weighed with care; the water contained being subtracted from it; lastly the portion which had been extracted from the mass in order to determine the water contained was made to pass over screens of 0.2, 0.5, 0.9, 1.6, 2 4 and 3.2 millimeters and the weight of each of the sizes produced carefully taken. Under these conditions the mill crushed 1350 kilogrammes of material per hour, while the stamps could pulverize only 855 kilogrammes

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the mill consumed 117 litres of water per minute, that is 5.21 litres per kilogramme of crushed ore; the stamp on the contrary consumed 450 litres of water per minute or 31.6 per kilogramme of crushed material.

The table (p. 233) gives the results of these experiments:

These figures show the superiority of the Schranz mill over the stamps, at least for the ore of Laurenburg. Considered from a general point of view, the results obtained by the use of this mill are certainly very favorable, inasmuch as it furnishes very little slime and gives, on the contrary, 43 per cent. of grains 0.5–1.6 millimeters and 15 per cent. 0.5–0.2 millimeters the treatment of which is easy.

In a second series of experiments products from 8–15 millimeters and 15–20 millimeters were submitted to be crushed. The results have been still very satisfactory, it is nevertheless necessary, in this case, to surround the plate with a sheet or a metallic fillet to stop and throw back the products which spread over the edge of the plate. This inconvenience is not experienced with grains of a coarseness between 3–8 millimeters. Also the complication resulting from the use of this sheet or fillet leads to the conclusion that the Schranz mill is especially useful for products finer than 8 millimeters, and if this restriction be made (as in the scheme of treatment at present followed at Laurenburg), and there be sent to the mill only materials of that dimension, excellent results may be obtained.

III.—Cleansing and Sizing.

I merely cite as a note on the operation of cleansing that the methods and apparatus used do not present anything new. These are either the bump sieves as in Saxony, trommels made of sheet-iron with blades projecting into the interior to break up the mass of material, or else conical trommels with longitudinal iron ribs.

Sizing is done on bump sieves in ordinary trommels or in the Schmitt-Manderbach apparatus which has recently come into use.

(*a*) *Method of Treatment.*—The succession of the holes in the screen plates, the diameters of which formerly increased in a geometrical ratio, is no longer the object of so exact a determination. It is rather by practical considerations that the German engineers have been guided, and notably by the desire to reduce the number of screens formerly greatly multiplied by the application of

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Size of Grains.	Weights given by 100 kilos of crushed ore.		Results from analyzing the crushed ore. Zn. (Per cent.)		Pb. (Per cent.)		Ag. (Grams.)		Weights of metals contained in weights corresponding to the various sizes. Zn. (Kilograms.)		Pb. (Kilograms.)		Ag. (Grams.)	
	Stamps.	Mill.	Stamps.	Mill.	Stamps.	Mill.	Stamps.	Mill.	Stamps.	Mill.	Stamps.	Mill.	Stamps.	Mill.
			Composition of Ore before crushing.											
			31.86	32.91	4 10	4.20	52	50						
			Composition of various sizes.											
3.2 mm. — 2.4 mm.	.....	6.95	.....	27.02	.....	3.32	...	52	.....	18.779	.....	2 307	.....	3 614
2.4 mm. — 1.6 mm.	4.68	21.07	17.81	29.89	1.32	3.28	20	52	8.335	62.978	0 618	6.911	0.936	10.956
1 6 mm. — 0.9 mm.	15.15	26.27	24.76	30.50	2.10	3.34	28	52	37.511	80.124	2.000	8.774	4.242	13 660
0.9 mm. — 0.5 mm.	16.96	16.92	28.74	31.40	2.22	2.88	28	32	50.439	53.129	3.765	4.873	4 749	5.414
0.5 mm. — 0.2 mm.	28.08	15.81	34.73	33 22	2.42	3.72	32	60	83 630	52.521	5.827	5.881	7 706	9.486
Total of all sizes greater than 0.2mm	60.87	87.02	.....	.....	.....	.....	...	...	179.915	267.531	12.210	38.746	17.633	43.130
Under 0.2 mm.....	16 72	7.21	35 63	31.86	7.10	9.02	94	120	59.573	22.971	11.871	6.503	15.717	8.652
First slime.....	5.87	2 23	32.76	28 99	7.32	6.40	96	94	19.230	6.465	4.297	1.427	5.635	2.096
Second slime.....	3.88	1.71	32.16	28 84	9.10	7.10	118	110	12.478	4.932	3.531	1.214	4.578	1.881
Products carried to the sediment basins with the water	12.66	1.83	.....	.....	.....	.....	....	.....						
Total of all sizes under 0.2 mm.....	39.13	12.98	.....	.....	.....	.....	...	.....	91.281	34.368	19.699	9.144	25.930	12.629
Grand total.....	100	100	A weight of 1000 — 126.6 = 873.4 kg. of ore pulverized by the stamps, contains.....						271.196	.....	31 909		43 563	
			A weight of 1000 — 18.3 = 981.7 kilograms of ore pulverized by the mill, contains.....						.....	301.899	.....	47.890	.....	55.759

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this rule. A very notable manifestation of this tendency is to be found in the works at Schulenberg (Hartz). The ore which is treated there consists essentially of galena, blende and copper pyrites. The copper pyrites is separated from the blende by hand-picking, the densities of these two bodies being too close to permit of their being separated otherwise. Thus they are forced to resort to a hand separation of the ore into two classes, "galena and blende" or "galena and copper pyrites." It is necessary then, if this theory is to be applied, to calculate the diameters of the holes in the trommels so as to separate the two bodies whose density has the closest ratio, that is to say, galena and copper pyrites. The corresponding geometrical ratio is $\frac{7.5 - 1}{4.2 - 1} = 2.03$ which gave the following series of diameters:

1, 2.03 4.669 9.478

Now, several years ago, the following series was adopted at Schulenberg:

1, 2, 3, 4, 5, 8, 10, 12.

Recently since the reconstruction of the plant the following series has been adopted:

1, 2, 3, 4, 6, 10, 15.

Which contains one trommel less and conforms less to the theoretical series (since the trommel of 5 millimeters which corresponds approximately to that of 4.669 has been suppressed). It has not yet appeared that the final classification has suffered in consequence.

(*b*) 1. *Apparatus: Bump Screens.*—This form of apparatus, which no longer exists except in old dressing works, notably in Saxony, is now definitely condemned.

2. *Trommels.*—The most advantageous dimensions for trommels are those which give the greatest production with the least loss. The increase in capacity may be obtained primarily by increasing the speed of rotation. But the centrifugal force throws the larger grains over the holes and impedes the passage through these of the finer particles, for which the centrifugal force is smaller. The increase of production then can practically be obtained only by increasing the diameter of the trommel; the diameter of the large

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base had not exceeded 65–70 centimeters until recently, and it is only within a short time that a trommel, the smallest diameter of which was 1.50 metres, was tried at Laurenburg. The product then spread over a much larger surface, and for a given quantity introduced the depth is less, and consequently the sizing is more rapid. This rapidity of sorting permits of reducing to 65 centimeters the perforated length of the trommel; a length which in ordinary trommels is not less than 1.25 metres. For the same reason the pitch of the generatrices may be carried to 10 in 100 instead of 5 in 100, as in normal trommels. This increase of the inclination together with the dimunition of the length has the effect of diminishing the length of time the refuse remains in the trommel, and consequently diminishes not only the formation of dust, but also the wear of the perforated sheet. This trommel with holes of 8 millimeters is used at Laurenburg at a speed of six revolutions per minute for the treatment of ores called spathic, which, as we will see in the second part of this paper, are washed in a special building.

The other details of construction of trommels do not merit any special mention. Their arrangement, on the contrary, presents interesting features.

The use of more than two concentric trommels is now completely abandoned, and if the height available is limited, as, for example, at Lautenthal, recourse may be had still to the use of double trommels, followed by a series of successive trommels. The two practical solutions which are actually in use are the arrangement in steps and side by side. In these two dispositions the axes of the trommels are at different levels, but, in the first case, the horizontal projections of the axes of these apparatuses are in the same line, whereas in the second they constitute a series of parallel lines, the extremities of which are limited by the same two vertical planes. These two solutions, which are both adopted in the recently reconstructed dressing works at Ems, each have their advantages and their inconveniences. The first has the advantage of requiring a smaller difference in height, and not only of rendering the replacement of a trommel, which has been rendered unserviceable, easy, but it also permits of introducing material directly into any trommel of the series. This disposition also permits the driving of the trommels from a single shaft, with a fixed and a loose pulley and a separate belt for each trommel. In this

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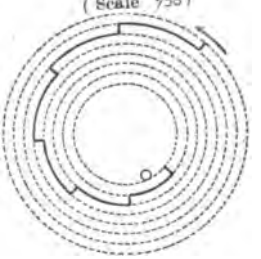
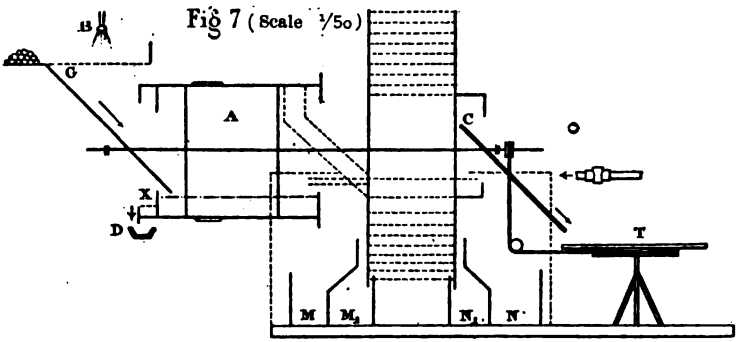
way it is possible to stop the movement of any trommel in the series, and to place inside of such trommel a strip of sheet-iron, so that the products introduced at the level of the highest trommel of the series traverse such trommels without being submitted to any sizing. The second disposition, which has the advantage

Fig. 6
(Scale 1/50)



of taking up less room than the former, does not permit such combinations, the utility of which is incontestable in works where the variety of ores treated necessitates modifications in the method of treatment. It is necessary, with this arrangement, to avoid complication by driving each trommel from the one adjacent, which

Fig 7 (Scale 1/50)



renders the stopping of single trommels in the series impossible.

3. *Schmitt-Manderbach Spiral Trommel.*—This apparatus is composed of a series of concentric plates perforated on part of their surface only, the blank portions being disposed in such a way that one does not cover another. These are fastened together by sheet-iron guide-plates in radial planes. These guide-plates, which join the extreme edges of two successive perfor-

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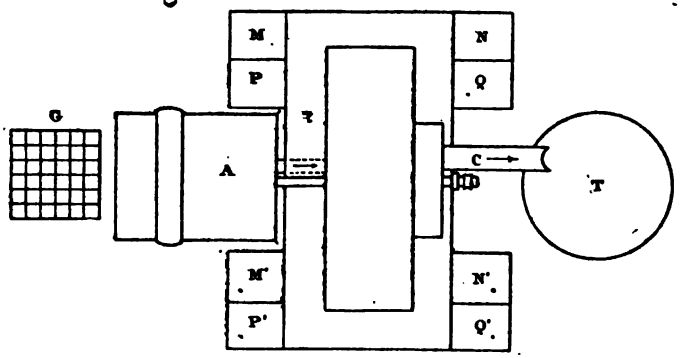
ated plates, keep back the refuse of the plate with the greater diameter.

Fig. 6 gives the section of the apparatus perpendicular to the axes. The refuse of each plate is discharged by a slightly inclined chute, nearly parallel to the axis of rotation, to a lateral chute. Each of these chutes being at a different distance from the trommel, allows the refuse of a given plate to be sent into a bin situated at any distance from the lateral wall of the apparatus; moreover, the presence of the interior plates (which prevent the refuse from any given screen discharging during the revolution) renders it possible to send this refuse into a stall situated at any distance

Fig. 8 (Scale 1/50)



from the axis of rotation. These stalls are denoted by the letters M N P Q M′ N′ P′ Q′ M_1 N_1, etc. On Figs. 7 and 8 of Plate I., the dimensions of the apparatus used at the works at Himmelsfürst (Saxony) are as follows, the plates being numbered from the inside:

	Diameter of Holes. Millimetres.	Diameter of Plates. Metres.	Perforated Surface. Metres.	Blank Surface. Metres.
1st Plate.....	15	1.06	2.00	0
2d "	10	1.22	2.10	0.20
3d "	7	1.38	2.34	0.26
4th "	5	1.52	2.57	0.29
5th "	2.5	1.66	2.81	0.32
6th "	1	1.80	3.03	0

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Width of the trommel, 0.600 metres.

Capacity, 2 cubic metres per hour, the apparatus making eight revolutions per minute, and requiring ½-horse-power.

No supervision is necessary other than that supplied by the ordinary machinists of the works.

Independent of the other advantages, which will be discussed later, this apparatus presents that of occupying a small space and of wearing out less rapidly than other trommels. On the other hand, it must be placed at a high level, a disadvantage which, in the case of a series of elevated trommels, is only presented by the first of these trommels. This disadvantage consists not only in the cost of installation of such an apparatus at a great height in the building, but also in the difficulty of inspecting from time to time the condition of its screen plates.

(To be continued.)

DESCRIPTION OF THE TOPOGRAPHIC WORK OF THE U. S. GEOLOGICAL SURVEY.*

By GERALD F. SHERMAN.

THE U. S. Geological Survey was originally organized for the purpose of exploring and locating the geological areas of the United States. Almost as soon as the work was commenced, it was found that a reliable map, on which to show the geology, was imperatively necessary. At present, the survey is occupied in making

* In the summer of 1892, the writer was enabled, by the cordial co-operation of the authorities at Washington, to make arrangements for the students in the summer school of surveying of Columbia College to join the topographical parties of the U. S. Geological Survey. A considerable number availed themselves of the opportunity thus given to learn the methods of the survey, so admirably well adapted to obtaining good topographical maps of large areas on the scale of one mile to the inch.

After the completion of the regular course at the summer school, the students were detailed in pairs to join parties working in the Catskills, Hudson Valley, White Mountains, and Maine, for a week's work.

Among the excellent reports and memoirs handed in, Mr. Sherman's has been selected for publication, after receiving very complimentary endorsement from Mr. H. M. Wilson, topographer in charge of the N. E. Division of the Survey.

JAMES L. GREENLEAF,
Columbia College.

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a series of contour maps on which the geological areas are to be subsequently indicated.

The map-making work of the Geological Survey may be divided into two parts—the office and field work. The office work consists in inking in the maps on which the field work is finished, and preparing them for the engraver; and in plotting the initial points on the plane table sheets to be used later. These initial points are located by triangulation, either by the Geological Survey itself or by the U. S. Coast and Geodetic Survey. They also use data, occasionally, that is furnished by other reliable surveys; for instance, the triangulations conducted by the New York State Survey, and the U. S. Lake Survey. In the East, the Geological Survey has to do very little triangulation of its own, as the Coast Survey has pushed its triangulation, in some cases far into the interior; even across Vermont and New Hampshire, and north of Albany. The field-work done by the topographers of the Survey consists in locating the roads, streams, and inhabited houses, generally by means of the plane table, and in sketching the contours on the skeleton sheets thus obtained.

The object of this memoir is to describe particularly the field-work which has to do with the detail of the map, and the triangulation of the Geological Survey will only be mentioned.

On taking the field in the spring, the parties usually consist of three men, the topographer in charge, the plane-table man, and the traverse man; though sometimes the parties are cut down to two, who divide the work somewhat differently. The plane-table work will first be taken up, next the road-traversing, and finally the sketching, as nearly as possible in the order of progress.

The Plane-Table Work.

The outfit used is particularly light and convenient, while sufficiently strong and steady for all ordinary work. The tripod has a quick-levelling attachment, consisting of a ball-and-socket joint, which may be clamped in any position, but has neither levelling nor tangent screws. The paper is very stiff, and is made of two thicknesses mounted together with the grain in different directions to prevent expansion and contraction in damp or dry weather as much as possible. The sheet is nearly as large as the table, and is screwed to it, not being removed or changed until it is finished. The sheets cover an area of 15′ of latitude by 15′ of

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longitude, and the 5′ lines of latitude and longitude are drawn in on a scale of $\frac{1}{45000}$. These lines and the primary triangulation points are plotted and inked in at the office before taking the field. There are no especial features in the rest of the apparatus.

The object of the plane-table work is to locate a sufficient number of points to enable the traverse man to accurately tie in his road traverses. The methods used in determining these points are those used in all plane-table surveys, the three-point problem, from its convenience, being often employed. It requires a little experience to decide which are points worthy of location, and having decided, to fix them in the mind so that they may be recognized and located from another station. Besides this, they must be described so that the traverse man may identify them with locations of his own. Their system of notes simpifies this to a certain extent.

Station XXVIII. was not located, having only one angle-line ("517") drawn through it. On setting up, the table was oriented by means of this line, and the point located and checked by several resections. Having obtained a satisfactory location, the remaining work of the station may be divided into three parts—the locating of stations to which lines have been drawn from other stations, the shots to new stations or intersection-points, and the vertical angle work. In all these divisions, the same order of work is followed. The stations to the south, for instance, are observed first, then those further west, passing around in this manner to the north and east, until all have been sighted. This method prevents to a great extent confusing and omitting points.

In the first part of the work the shots are numbered, the numbers having been carried on continuously from the beginning of the sheet. These numbers are placed in the column headed "No." Then the notes are examined until the number of the other shot to the same point is found and entered on the same line in the column headed "Equals." This first line may be called the direction line and the second the locating line. The number of the locating line is then entered in the "Equals" column on the line with the number of the direction line. This system shows that the point is located, giving the numbers of both lines in both places where any mention of the object is made.

In the second part direction lines are taken to new points. The number of the line is entered as before in the "No." column;

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Copy of Notes taken at Station XXVII. of the N. E. ¼ of the Cohoes Sheet.

"517" Station XXVII., September 20th, 1892.

"No."	Equals	V.A.	Dist.	Elev.	
548	519	— 3°18′	.....	.....	
549	518	.....	.....	.....	
550	412	.....	.....	.....	
551	515	— 1°15′	.....	.....	
552	516	.....	.....	.....	
553	544	— 0°33′	.....	.....	
554	538	— 0°07′	.....	.....	
555	364	— 0°53′	.....	.....	
556	...	— 1°41′	.....	.....	White house 1 mi. N.E. of station. Red building north.
557	...	— 1°37′	.....	.....	Yellow house, black roof, 2 mi. N.E. of stat'n.
558	...	— 1°23′	.....	.....	White T. K. on large gray barn, 2 mi. N.E of station, red-roofed houses.
559	...	— 1°06′	.....	.....	Large red barn, length E. & W., 2 mi. N.E. of station, white houses.
560	...	— 0°33′	.....	.....	T. K. on old barn, length N. & S., 3 mi. N.E. of station, cornfield S.
561	...	....	.....	.....	Large yellow house, red shutters, 1 mi.N.of sta.
562	...	— 1°53′	.....	.....	Old gray barn, length N. & S., in field 1½ mi. E. of station.
563	...	.....	.....	.....	Yellow barn, length N. and S., ¾ mi. E. of sta.
564	...	— 1°32′	.....	.....	Large farm house, 2½ mi E. of sta., near R.R.
565	...	.....	.....	.....	Small red barn. length N. and S , 2 mi.E.of sta.
566	...	.....	.....	.....	Centre of long, low shed, length N. and S., 2½ mi. S.E. of station.
567	...	— 2°41′	.....	.....	Upper water-tank at Johnsonville.
568	...	.....	.....	.....	Small T. K. on new church at Johnsonville.
569	...	— 1°33′	.....	.....	White T. K. on church S. of Johnsonville.
570	520	— 1°28′			
571	...	— 1°07′	.....	.....	White house, west of red barn, 2½ mi. S. of sta.
572	...	.....	.....	.....	Red house, ½ mi. south of station.
573	...	— 1°23′	.....	.....	Big square white house, flat roof, yellow buildings S., 2½ mi. S.E. of station.
574	...	.....	.....	.....	Small apple-tree in plowed field on cleared hill 5 mi. S. of station.
575	...	.....	.....	.....	Elm-tree on same hill
576	...	— 1°48′	.....	.....	Large red barn, length E. & W., gable centre N. and S., white house W., 2 mi. S. of sta..
577	...	.....	.....	.....	Top of bare hill 5 mi. S W.
578	...	.....	.....	.....	Wooded knoll 3 mi. S. of station.
579	...	— 1°34′	.....	.....	Large T. K. on brick mill in Schaghticoke.
	Sta. X.	— 0°45′			
	Sta.XXIV.	— 1°23′			
580		.....	.....	.....	R. R. crossing ½ mi. east of station.

the "Equals" column is of course left blank for the number of the locating shot, and a short description of the point is given on the opposite page.

The vertical angle work consists in reading the angles to most

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of the points, and to almost all of the stations that can be seen. Reading to different stations gives a system of checking elevations by making them interdependent one on another. It is a method of reciprocal adjustment. The vertical angles are read generally to the ground at the location. When this is not the case, an explanatory note is entered with the description on the opposite page. When convenient, usually at night or on rainy days, the distances between the points and locating station are read off on a scale, and the vertical heights corresponding to the distances and their respective vertical angles are taken from a table in which allowance is made for the curvature of the earth, refraction, etc. The results are the differences in elevation between the station and observed points. They find that in the vertical angle work very long shots are not desirable; that there is a limit beyond which the work does not check very well. This limit is about eight or ten miles for the scale under consideration. Otherwise the vertical angles check remarkably well, usually within ten feet; in fact, rarely exceeding that limit.

The plane table work is very good, intersections and resections checking almost exactly. Every possible advantage is taken of circumstances. The shots to the important stations are taken in the morning and evening when possible; to the western stations in the morning and to the eastern in the evening, when the sun will be shining directly on the object and not into the telescope.

Road Traversing.

The instruments used in road traversing are the traverse table with its alidade, and a buggy-wheel which is used in measuring distances.

The traverse table consists of a board about 18 inches by 18 inches, mounted upon a light tripod similar to that of the large table. The board has set into it a declinatoire, and the table is always oriented by its means unless there is evidence of a large amount of local attraction. This necessitates the paper being fixed in position. The alidade is merely a metal straight-edge to which a pair of compass-sights have been attached, with the line of sight parallel to the fiducial edge.

The buggy-wheel is measured, usually by stretching a tape around its circumference, and its revolutions are counted by the traverse man. This method is found to be as accurate and much

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more convenient than any odometer or cyclometer in use. To assist the counting, a rag is tied to one of the spokes. The scale used, $\frac{1}{45000}$, is divided into one hundred parts, a mile being taken as the unit. The number of wheel revolutions to the smallest scale division is calculated, and a small table is made to convert wheel revolutions to scale divisions. This may be tacked to the traverse table for convenience in using.

Any convenient point is taken as a starting-point, and its position is assumed upon the traverse sheet. Setting up at this starting-point, the table is oriented with the compass, after being levelled by the eye, as there are no level-bubbles. Shots are taken down the road or roads in both or all directions. Then getting in the buggy, the wheel is counted to the next turn or bend in the road. The number is noted and a new count commenced, which continues until the second bend is reached. Then the table is set up and oriented as before. We have plotted the first line of the road from the first station. Laying off the distance to the first bend, we locate that point. But the road is straight between that point and the point at which the table is now set up. So, resecting on the line of road between them, we lay off the second distance and obtain the position of the table. By repeating this operation a road may be run for any distance. After all the roads in the vicinity are traversed, they form a network which checks and ties itself together.

While the road traversing is going on, many other points are located off the road; by intersections, in the more accurate locations, or by offsets, for instance, to houses close to the road. In this way streams crossing the road and all inhabited houses are located, together with all important objects which may, by any chance, have been located by the large plane table. Locations off the road which may assist the topographer are also taken. These are usually the tops of hills or points lying on the edge of a bluff, etc. In some cases, when a piece of important topography lies at a distance from any road, the traverse man may go so far as to run a line of triangulation over to it, but this is rarely necessary.

In the evenings the traverses are "adjusted" with the assistance of the points located by the plane table, and the rood skeleton is transferred to another sheet. There are four of these sheets to go with each plane table sheet, each 7½ minutes Lat. by 7½ minutes Long. (one-quarter of the large sheet), plotted to the same scale.

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To the proper one of these quarter sheets are transferred, with the assistance of tracing paper, all the points located in that quarter of the plane table sheet. Then a small portion of the road traverse, with the locations which the plane table and traverse sheets have in common, is traced very carefully and laid over the quarter sheet, applying common points to each other. This tracing may not fit exactly, but it is adjusted to the best advantage, and the points are pricked through. All the matter of the traverse sheet is thus transferred to the quarter sheet, and it is then inked to prevent erasure or smearing in the process of stretching. This material furnishes the "instrumental control" on which the contours are sketched.

Although this method seems very rough, it is surprisingly accurate—practically as accurate as the transit and chain traverse, which it has superseded. It has the decided advantages over the transit traverse of being much more rapid and making possible the location of any number of points off the road. If any mistake is made, the adjustment of the traverse shows immediately where it is, so that it may often be corrected without going into the field. With the transit there are many calculations to be made before the traverse can be plotted and used by the topographer, while if there is a blunder it will perhaps not be discovered until plotting, which may not occur until the following winter. Locating points off the line, too, will take so much time that few can be afforded.

The Sketching of Contours.

The topographer sketches on these quarter sheets contours at a vertical interval of 20 feet, having the assistance of an aneroid barometer and knowing the elevations of a number of plane table locations. The sheet is usually tacked to a small board.

He starts at any point on a road and makes as small a circuit as he can, following roads; sketching, as he goes, the contours that cross the road; and taking his elevations from an aneroid which he has set to read correctly at a point of known elevation. He sketches these contours in, as far as he can follow them, on each side from the road, using the points located by the road traverses and plane table to check his bearings, distances, and elevations. Usually, by the time he has completed his circuit he is able to join the ends of the contours drawn from different sides, and finish the portion enclosed without leaving the road. In cases where the enclosed

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area is very large and there is a space which cannot be seen from any point of the road, he is obliged to walk over and sketch in the omitted part, pacing distances and checking positions, as before, on the located points. The work is greatly strengthened by sketching in a circuit, as it enables one to observe the contours from several different points and modify one's ideas to fit the real shape of the ground. Joining the contours sketched from different roads is also a good check, and helps the work done from both roads. The sketching is greatly assisted by numerous locations off the road in the proper places, and the traverse man would do better to have too many auxiliary points than too few.

The aim of the contours is to give a correct idea of the form of the country, and in order to do so the topographer occasionally exaggerates slightly. For instance, if a flat-topped hill has a knob at one end that does not quite reach a certain contour, a contour may be drawn around the top to show that there is a knob, and which end of the hill is higher.

The aneroid is set at the beginning of the day, and is compared as often as possible with known elevations. On some days it stands very steadily and does not have to be changed, while on others it has to be continually watched and reset as check-points are reached and circuits closed.

Beside sketching the contours and drainage, the topographer dots in the woodlands to furnish data for an estimate of the timber lands of the United States.

The sketching is by far the most difficult part, and to sketch well a great deal of experience is necessary. The object of the work is seen at a glance. Practice, and in most cases a great deal of practice, is the only means which will enable one to arrive at the desired result.

This finishes the field work.

In the winter the quarter sheets are fully inked in, and photographed down to a scale of $\frac{1}{62500}$ on very thin paper. These photographs are then transferred to the final sheet by blackening the back of the paper and tracing over the lines with a sharp ivory point. The final sheet is then very carefully inked in and lettered. The field work should be carried beyond the boundaries of the quarter sheets a little to assist in joining them together. The finished whole sheet is next engraved upon three copper plates; one for the black, for "culture" and lettering; a blue plate for water; and

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a brown one for the contours. From these plates lithographic stones are prepared, and a few proofs printed, which are sent for correction to the topographer who made the survey. When the proofs are approved, the sheet is printed.

This memoir was written from data obtained during a stay of a week with a party at work on the "Cohoes sheet," consisting of Mr. Frank Sutton, topographer, and Mr. Wheat. As only one party was observed, the methods described may differ in some slight degree from the general practice of the survey.

A MODIFIED HOFMANN APPARATUS.

By N. HATHAWAY, Ph.B.

The figure represents a modified Hofmann apparatus which serves also as a voltameter and furnishes either electrolytic gas, oxygen or hydrogen as required.

The tubes A and B are graduated from the upper stopcocks to 50 c.c. in fifths. The tube A is enlarged at D so as to contain the two platinum electrodes. The level and overflow tube C is supported so as to be readily raised or lowered and is furnished with a stopcock to draw off superfluous fluid.

The stopcock E, connected with the three tubes by rubber tubing, is so bored that either all three tubes are connected or the level tube C is connected with either A or B. This permits the evolved gases to be measured at the pressure of the atmosphere.

The apparatus was furnished complete by Mr. Emil Greiner, of New York.

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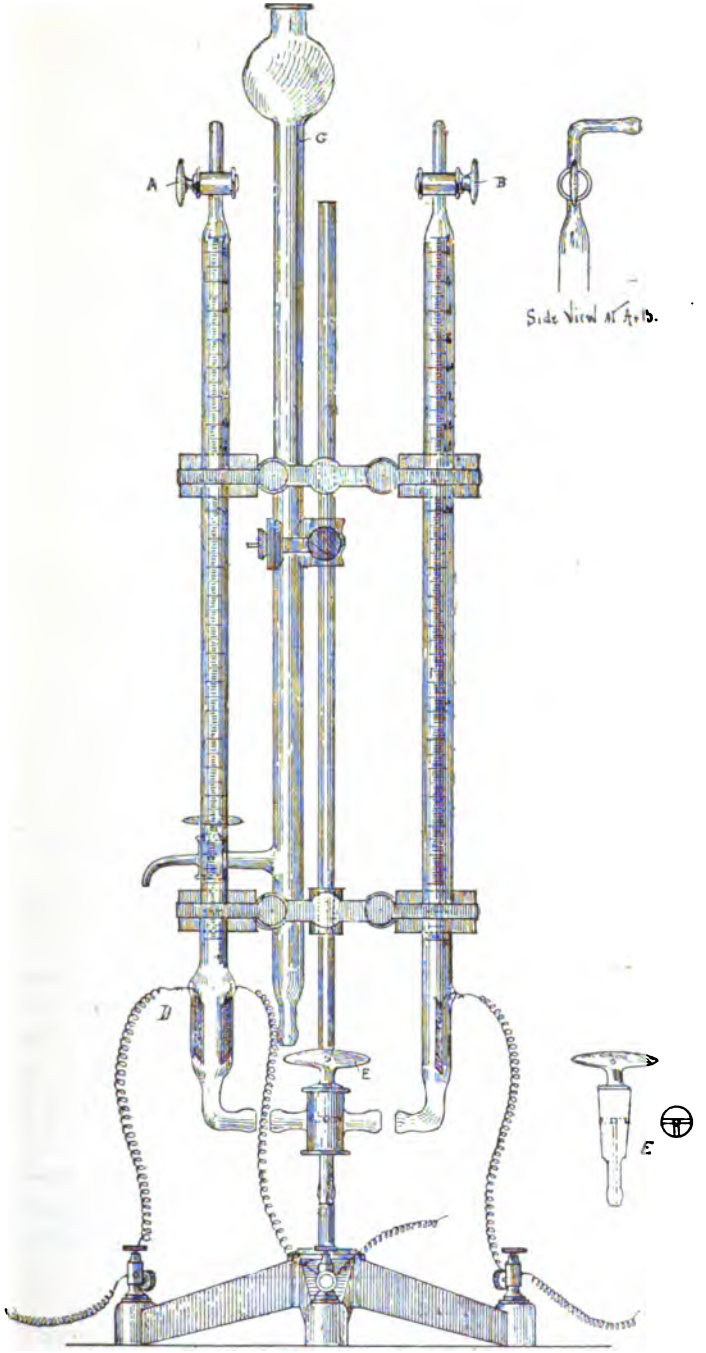

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ON EDUCATION.

(Address by Prof. Anton v. Baeyer on his inauguration as Rector Magnificus of the University of Munich, November 25, 1892. A newspaper abstract.*)

TRANSLATED BY GRAHAM LUSK, PH.D.

PROF. v. CHRIST (the retiring rector) has referred to the instruction in the branches of natural sciences as examples of what should be, and has especially praised Liebig's laboratory, saying, with change in names, what Cicero said of the School of Socrates, that from it went forth the foremost men of Greece. This high praise of Liebig's laboratory is certainly pleasant to one who has devoted his whole life to keeping alive the traditions of the school of Liebig. It seems my present duty to explain wherein lies the fundamental superiority of this system of instruction.

If Liebig had owed his reputation as a teacher to his attractive personality, consideration of his deeds would merely have historical value. But his methods of instruction depended upon a train of thought which still has its worth. These ideas did not come gradually to Liebig during his career as instructor, but they were the fruit of his student days, derived from observation of his own intellectual developement. In fact there is no better way to learn how to teach, than to query how one learned oneself.

Liebig was the son of a dealer in dye-stuffs at Darmstadt, and made many interesting observations in his father's laboratory. On perusing his father's books, he attained the faculty of "thinking in phenomena." In school Liebig was a poor student, and once, after a severe scolding from his professor, was asked what he would ever amount to; his answer, "I will be a chemist," brought forth a scornful laugh. Likewise, in the apothecary's shop to which Liebig was sent, he was unsuccessful. Helmholtz, in his address on his seventieth birthday, tells us that he, like Liebig, passed badly in languages and history, and relates how during a recitation in Cicero he studied the refraction of light under his desk. On consideration of such facts from the lives of great men like Liebig and Helmholtz, though we may not divine the receipt

* *Münchener Neueste Nachricten.*

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for developing their counterparts, still we may discover valuable hints for university education.

The great fault in young men is lack of interest for any particular subject. We hear parents complain that the most difficult thing is selection of a calling, and usually some external influence causes a young man to accept this or that occupation. This failing has often been referred to the evil influence of the school, but this is carrying it too far. Schools certainly labor under many deficiencies, and examples like Liebig and Helmholtz are not necessary to show that the schools alone are not all-powerful in youthful developement. In my opinion the fault lies in our manner of life, that people see too much of each other. The youthful mind must have quiet, if it is to gain interest in any subject. The youth should be alone as much as possible. If one follows the early history of celebrated *savants*, one finds that they have all sought out solitude. Those who frequent the university and have no decided interest for any subject need not therefore despair. There is a possibility of winning this interest even in later years, but if the awakening comes late, a special concentration of the mind is necessary. If the student does not advance so that questions arise which he seeks to answer, then he can never fully enter into his subject; and these questions can only arise when, after completed work, he waits in quiet for them. From these questionings comes learning itself. Helmholtz says that, as far as his experience goes, great thoughts never come to the tired mind, and never at one's desk. He describes how his best thoughts have come to him during lonely walks in the woods—and likewise adds that the smallest quantity of alcoholic stimulants frightens them away. These words of Helmholtz should be remembered.* Hard work is necessary, but that is not enough. After recuperation from the work there should follow hours of quiet solitude in which the impressions received will have time to arrange themselves in the mind. Then occurs the phenomenon which we like to compare to the lifting of a veil, and, entirely of

* The translator has often met Prof. Baeyer walking alone in the "Anlagen" secluded parks along the river Isar near Munich. The professor clearly believes the truth of at least the first half of Goethe's saying:

"Es bildet ein Talent sich in der Stille,
Doch ein Character in dem Strom der Welt."

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themselves new ideas spring up giving inducement to renewed endeavor.

The home discipline of Liebig had most to do with his failure at school; under better influences he could easily have accomplished his tasks. Liebig afterwards made up in the university the weak points in his general education. His further advancement was under Gay-Lussac in Paris and Alexander von Humboldt, both of whom exercised powerful influence over him. Finally Liebig came to found his famous laboratory at Giessen. It did not satisfy Liebig to draw the attention of his students to the more modern facts, but he wished to place the beginner where, out of the whole historical knowledge he could select the truth. First well educated in the older literature, new ideas did not originate illogically, but intimately connected with the older views. He required, therefore, not only the present learning, but also the path upon which that learning had been obtained. After this manner Liebig founded the principles of his instruction, now more and more widely adopted. The student is taken back to the position of the first discoverer before his discovery. Seeing with the older *savant's* eyes and thinking with his thoughts, the student is inappreciably led up to the state of knowledge of to-day; the same current brings him still further and gives him glimpses of fields still unconquered.

Liebig's course of instruction was divided into two parts, one for beginners, the other for advanced students. He not only held lectures, but the students were immediately taken into the laboratory, and there was likewise constant quizzing on the part of the assistants. A further detail of Liebig's educational system was the introduction of independent scientific research. To-day in all well organized laboratories, similar work is carried on. This reformation is perhaps the greatest achievement of Liebig, and we honor him as the model of a German professor.

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ADDITIONS TO THE BIBLIOGRAPHY OF DR. J. S. NEWBERRY.

(*Continued from page 111.*)

THE following additions to the above list have been kindly suggested by Professor L. F. Ward, of the U. S. National Museum, and by Professor H. L. Fairchild, of Rochester, N. Y.

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ABSTRACTS.

Analytical Chemistry, E. Waller.

Distillation with Superheated Steam. Jaffe (*Berichte*, xxvi., 123) describes an original arrangement for this purpose. At the end of a series of condensers, etc., is attached an exhaust. The distillation is conducted in a tubulated retort, through the tubulure of which passes a glass tube bent at a right angle. The open external end of this tube is close to a Bunsen burner, so that by the operation of the exhaust the flame and heated products of combustion are drawn through the liquid which is to be distilled.

Purifying Commercial Zinc. Lescoeur (*Comptes Rend.*, cxvi., 58). By the double treatment of the zinc with KNO_3 and then fusion with $ZnCl_2$, a product free from As, Sb, S and P is obtained, It may still contain Fe, Pb, Cu, etc., but is suited for use in the Marsh apparatus, etc.

Sensitive Litmus Solution. Lüttke (*Apotheker Ztg.*, 1891, 643). Extract 100 gms. commercial litmus three or four times with warm water. Evaporate the extract to about 200 c.c. Acidify with 20 to 25 per cent. HCl, and dialyse through parchment paper until all HCl is removed. The remaining solution is exceedingly sensitive. Precipitate with alcohol and dry, or spread on glass plates and dry in a current of CO_2.

Borax for Standardizing Alkalimetric Solutions. Rimbach (*Berichte*, xxvi., 17). Borax recrystallized twice or thrice from the commercial salt is recommended. One gramme of crystallized borax will neutralize 5.2391 c.c. of normal acid or one litre of normal acid corresponds to 190.872 grammes of crystallized borax.

Preserving Normal or Fractional Normal Solutions of Oxalic Acid. Gerland (*J. S. C. I.*, x., 25). The addition of a small amount of thymol is recommended. The agent may also be used in standard solutions of tartar emetic.

Nessler-re-agent. de Koninck (*Fres. Zts. Anal. Chem.*, xxiii., 188). This reagent, so delicate for NH_3 in aqueous solution, gives no precipitate or coloration in alcohol solutions. On the other hand, the presence of alcohol does not interfere with Böhlig's test ($HgCl_2$).

Alkalies in Silicates. Low (*Jour. An. and App. Chem.*, vi., 666). Treat one gramme with HF and H_2SO_4 in a platinum dish. Evaporate and heat until fumes of SO_3 nearly cease; cool; add a little ammonia, and boil. Filter; add slight excess of $BaCl_2$; boil and filter. Evaporate to dryness in platinum dish, and heat to expel ammonia salts;

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cool; add $(NH_4)_2CO_3$ and ammonia; boil and filter; evaporate to dryness in weighed platinum dish, and obtain weight of combined chlorides.

Determination of Potassium. Hilgard (*Fres. Zts. Anal. Chem.*, xxii., 184) ignites the K_2PtCl_6 to decomposition in an old worn-out platinum crucible, the lower half of which is filled with Pt sponge, which has been heated sufficiently high to form a coherent filtering bed. The crucible is used for filtering in the same manner as an ordinary Gooch crucible. The KCl resulting from the decomposition of the salt may be volatilized partially or entirely by a strong heat, instead of washing it out. The contact of the Pt sponge favors the decomposition. After igniting and weighing, a drop of strong HCl should be added. If it shows a yellow color, the decomposition was incomplete or some iron salt was present.

Reduction of K_2PtCl_6. Bornträger (*Fres. Zts. Anal. Chem.*, xxiii., 188). Dissolve in hot water, and add solution of potassium soap (oleate). The compound precipitates in slimy and sandy flocks, consisting of a double salt of KCl with platinum oleate. Decant the clear solution, transfer the precipitate to a platinum crucible, ignite, wash off KCl and weigh Pt.

Solubility of Chloroplatinates. Peligot (*Monit. Sci.*, vi. [4], 872). In one litre of alcohol of strength given there will dissolve: K_2PtCl_6,—of 50 per cent., 0.6 gramme; of 90 per cent., 0.1 gramme; of 95 per cent., 0.03 gramme. Na_2PtCl_6,—of 60 per cent., 110 grammes; of 95 per cent., 22 grammes.

Determining Potassium as Perchlorate. Caspari (*Zts. angew. Chem.*, 1893, 68). The method of preparing the perchloric acid is minutely described. It consists in heating $KClO_3$, and then treating the resulting material with H_2SiF_6.

Potassium may be separated in the presence of most of the bases usually occurring, as well as in the presence of most acids, sulphuric only excepted. When sulphates are present, the boiling solution of 5 grammes of the material (about 150 c.c.), acidified with 20 c.c. of HCl, receives the addition of an excess of $BaCl_2$, is cooled, made up to a convenient bulk (250 c.c.), the precipitate allowed to settle, and aliquot portions taken out for the determination. This solution, or (in case sulphates were not present) the original solution, is evaporated until HCl is expelled, the mass dissolved in 20 c.c. hot water, and about 1½ times as much perchloric acid added as will suffice to combine with all the bases present. The mixture is then evaporated with stirring, until all odor of HCl has disappeared and white fumes of $HClO_4$ begin to show. It is then cooled, and the syrupy mass is well stirred with about 20 c.c. of 97 per cent. alcohol containing 0.2 per cent of $HClO_4$. Wash once or twice with this alcohol, decanting upon an asbestos filter. Warm up the residue to remove alcohol and heat again with about 0.3 gramme $HClO_4$ and a little water, and wash with the perchlorate alcohol as before. The entire amount of alcohol used in washing should be 35 to 70 c.c. Larger amounts cause error by dissolving the precipitate.

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It is advisable to loosen $KClO_4$ crystals from the dish (if need be) by a clean finger tip, rather than by use of much alcohol.

Aluminum in Steel, etc. Schöneis (*Stahl und Eisen*, xii., 527). Five to ten grammes of the sample are dissolved in HNO_3 (Gr. = 1.2) in a platinum dish, the solution evaporated to dryness and heated to expel N oxides. The residue is pulverized, fused with pure KOH, leached out with water, and the Al separated as hydrate by the use of HCl and ammonia. In the case of some steels the ignited precipitate will contain SiO_2, which must be removed by treatment with HFl.

Analysis of Commercial Aluminum. Rossel (*Chem. Ztg.*, xvi., 4). Dissolve gradually 3 to 4 grammes in 35 c.c. of 30 to 40 per cent. KOH, without filtering, supersaturate with pure HCl, and evaporate to dryness in platinum. Moisten with HCl, take up with H_2O, and filter off SiO_2. The reagents must, of course, be free from SiO_2. For Fe, dissolve in the manner described, add excess of dilute H_2SO_4, warm until the solution clears, and titrate with standard permanganate.

Ferric Oxides and Alumina in Phosphates. Smethain (*J. S. C. I.*, xii., 112). For many grades of phosphates 3 per cent. Fe_2O_3 and Al_2O_3 is allowed, but any excess counts double as against the phosphate, *e.g.*, a sample showing 80 per cent. $Ca_3(PO_4)_2$ and 3 per cent. Fe_2O_3 and Al_2O_3 would be invoiced at 80 per cent., but if it contained 4 per cent. Fe_2O_3 and Al_2O_3 it would be invoiced at 78 per cent.

The old acetate method worked upon the assumption that $FePO_4$ and $AlPO_4$ are insoluble in cold acetic acid whereas $Ca_3(PO_4)_2$ is soluble, was faulty in assuming that the precipitate consisted of normal phosphates aud that $AlPO_4$ was insoluble in excess of acetic acid.

Glaser's method as modified by H. H. B. Shepherd (*Ch. News*, lxiii., 251) is satisfactory in results if carefully performed.

The author usually checks the Glaser method against his own (acetate of ammonia) method. This consists in evaporating 2 grammes with HCl,—taking up with about 10 c.c. of HCl, digesting, diluting and filtering. The solution is then boiled with H_2O_2, cooled, and dilute ammonia added until a slight permanent precipitate is obtained. The solution is cleared by cautious addition of HCl, ammonium acetate added, and after stirring it is set aside for some time, when it is filtered and the precipitate washed first with cold, finally with hot water, dried, ignited and weighed. This precipitate consists of ferric and aluminic phosphates, with some calcium phosphate. It is dissolved in dilute HCl, citric acid added and then $(NH_4)C_2O_4$. It is boiled and neutralized with ammonia, and then rendered distinctly acid with acetic, and kept simmering for some time, which separates the lime. In the filtrate P_2O_5 is separated by magnesia mixture, and in that filtrate Fe is separated by $(NH_4)_2S$, the Al_2O_3 being obtained by difference. The process described by Wyatt (*Phosphates of America*) did not give very satisfactory results.

Separating Iron from Alumina. Bornträger (*Fres. Zts. Anal. Chem.*, xxiii., 187). Precipitate the Fe_2O_3 and Al_2O_3 together, ignite and weigh. Dissolve in HCl (?), render nearly neutral with KOH, and pre-

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cipitate hot by addition of solution of potash soap (oleate), filter, wash the precipitated oleates with hot water to remove KCl, dry off the most of the water by placing in a desiccator over $CaCl_2$. Extract the Fe_2O_3 soap with hot petroleum and then ignite the Al_2O_3 soap and weigh pure Al_2O_3. The petroleum may be boiled off and the residue ignited to Fe_2O_3 if a direct determination of that oxide is desired. Ferrous iron may be separated in the same manner.

Rough Test for Titanium in Ores. Rossi (*Trans. Am. Inst. Min. Eng.*, February, 1893), gives the following: Heat a fragment of the ore to hardly dull red, and plunge into water. The piece then crumbles readily on the slightest shock and if the TiO_2 present is 6 to 20 per cent. or more, it assumes the blue color of blue schorl or anatase (octahedrite). If the blue color does not appear TiO_2 is absent or present only in small proportion.

Manganese in Ores. Low (*J. Anal. and App. Chem.*, vi., 663). The solutions necessary are permanganate approximately tenth normal, oxalic acid (cryst.) solution, 11.46 grammes per litre. These should be standardized and their relation to one another determined. Cold saturated solution of Br in water. Dissolve 0.5 gramme of ore in a flask by use of 5–10 c.c. HCl or aqua regia. Heat until most of the free acid is expelled. Dilute with 75 c.c. H_2O. Add excess of ZnO—boil; then add (not over 50 c.c.) Br water, and boil out excess of Br. An excess of ZnO should still remain. Filter and wash; return the precipitate to the flask—add about 50 c.c.; dilute H_2SO_4 (1:9). Run in excess of oxalic solution from a burette, heat, dilute and titrate the excess of oxalic with the permanganate. The analysis may be carried through in twenty minutes.

Nickel Determination. Syssoyeff (*Monit. Sci*, vi., [4], 865). The Ni is converted into 2 KCy, $NiCy_2$ by use of KCy avoiding an excess. On passing a current of Cl through this solution $Ni_2(OH)_6$ is precipitated. The precipitate is collected on an asbestos filter and treated in a Lunge nitrometer with a strongly acidified solution of H_2O_2 and the gas measured. The reaction is: $Ni_2O_3 + H_2O_2 = 2\ NiO + H_2O + O_2$. A correction must be applied for the O which is always in solution in the H_2O_2 solution.

Management of the Precipitate Produced by H_2S in Acid Solutions. Antony and Niccoli (*Gazz. Chim.*, xxii, 408). PtS_2 and Au_2S_3 are only partially soluble in $(NH_4)_2S$.

The sulphides are boiled for a short time with HCl of specific gravity 1.11, air being excluded so far as possible. This dissolves Sb, Sn, Br, Cd and Pb. The insoluble sulphides remaining, after thorough washing, are boiled repeatedly with HNO_3 (specific gravity 1.2). As and Cu are dissolved, while Hg, Au and Pt sulphide remain undissolved. The other operations are conducted by well-known methods. In the first operation here described, the exclusion of air is especially necessary to prevent solution of Cu in the boiling HCl.

Electrolytic Copper. Hampe (*Ch. News*, lxvii., 103), finds that in the

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electrolytic separation of Cu from a sulphate solution containing free HNO_3, Sb, if present is always precipited simultaneously with the Cu, the amount deposited increasing toward the end of the operation.

Lead by Electrolytic Separation as PbO_2. Dudley (*J. Anal. and App. Chem.*, vii., 5). The precipitate of PbO_2 by this method may be contaminated with Bi, if that element is present. It may also contain traces of Fe, Sb and Sn.

Volumetric for Mercury. Namias (*Gazz. Chem. Ital.*, xxi., 361). The Hg must be in the form of $HgCl_2$. Titrate with standardized $SnCl_2$ (2 to 4 grammes of the metal per litre), using as indicator filter paper soaked in Na_2MoO_4, which turns blue with a drop of the solution as soon as $SnCl_2$ is in excess. Hg_2Cl_2 is precipitated.

Determination of Arsenic. Backstrom (*Fres. Zts. Anal. Chem.*, xxxi., 663). The sulphide, separated by any approved method, is converted by HNO_3 into As_2O_5 and the H_2SO_4 expelled by careful heating at a temperature below red heat. With a little practice the intensity of the heat may be kept within the proper limits; the As_2O_5 is then cooled and weighed.

Arsenious and Antimonious Oxides. A. Baumann (*Zts. angew. Chem.*, 1892, 117). These oxides reduce potassium ferricyanide in alkaline solution. Hence a known amount of that reagent before and after reaction with either As_2O_3 or Sb_2O_3 evolves different amounts of O when treated with H_2O_2. The difference in the amount of O obtained serves as the measure of the amount of As_2O_3 or Sb_2O_3 present 1 c.c. oxygen = 4.425 mgms., As_2O_3 or = 6.4573 mgms. Sb_2O_3.

Tin in Bronze. Dudley (*J. Anal. and App. Chem.*, vii., 5), remarks that the metastannic acid separated by dissolving the bronze in HNO_3, etc., is never pure, but should be dissolved in $(NH_4)_2S$ the solution filtered and the SnS_2 reprecipitated.

Western Methods. Croasdale (*J. Anal. and App. Chem.*, vi., 671). The tests usually made on ores are as follows:

For *SiO_2 and Ba SO_4*.—Decompose with HCl or aqua regia, evaporate to dryness, take up with strong HCl, filter, wash with H_2O, then with hot solution of $NH_4C_2H_3O_2$ to remove $PbSO_4$, then with hot water, ignite and weigh. If $BaSO_4$ is present, fuse with alkaline carbonate, leach out with water, dissolve residue in HCl, and precipitate with H_2SO_4. The material left by the first evaporation after deduction of $BaSO_4$ is reckoned as SiO_2, H_2SO_4 being added (if necessary) while evaporation is in order to leave all Ba with the SiO_2. Slags are managed in essentially the same manner.

For *Fe.*—The filtrate from the insoluble residue is titrated by $K_2Mn_2O_8$ or $K_2Cr_2O_7$. For CaO a separate portion is dissolved in HCl, with addition of a little $KClO_3$, dilute and filter. To this ammonia is added to alkalinity then strong oxalic acid solution until it is acid, then ammonia a second time until the solution is alkaline or until a brown color is produced, when it is rendered acid with $H_2C_2O_4$ boiled and fil-

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tered. After thorough washing, the precipitated CaC_2O_4 is dissolved in hot dilute H_2SO_4, and titrated with standard permanganate.

Zn.—Von Schultz and Low's method is usually used, *vid.* QUARTERLY, XIV., 65.

Pb.—The fire assay is usually the standard for sales. Various wet methods are used. The most common one is the $K_2Cr_2O_7$ method. The Pb of the ore is converted to sulphate, filtered off, dissolved in $NH_4C_2H_3O_2$ and the solution titrated with $K_2Cr_2O_7$ using a spot test with $AgNO_3$ as indicator. With low Pb this method shows about 3 per cent. higher than the fire assay, but for high Pb it does not come up to the fire assay.

Cu.—KCy method usually used. In some works the electrolytic method is used.

Mn.—Iles' method is chiefly used, essentially the same as that described by Low, *vid. supra.*

S.—Fusion with alkaline nitrate and carbonate is used by some. The methods usually preferred, however, consist in oxidizing by HNO_3 with or without HCl, $KClO_3$, KBr, etc.

As.—Pearce's Ag method is usually used. The neutralization for precipitation, is frequently done with ZnO, instead of ammonia.—Canby, *Trans. Min. Eng.*, xvii., 77.

Determining Fluorine. Carnot (*Bull. Soc. Chem.* [3], ix., 71). The method proposed is mixing the material with ten times its weight of finely pulverized quartz mixed with one-fifth its weight of calcined silica (precipitated?) 0.2 grammes of material if chiefly fluorspar or cryolite, or 2 to 5 grammes of apatite or similar material mixed with 2 grammes of the quartz, etc. This is treated with absolutely anhydrous H_2SO_4 at a temperature gradually raised to about 160° C. in a slow current of air, dried by passing through conc. H_2SO_4. The SiF_4 is passed (under Hg) into a 20 per cent. solution of pure KF. Alcohol is then added to this solution and the K_2SiF_6 filtered, washed, dried and weighed. A rigid exclusion of all aqueous vapor is absolutely essential. A blank should be run preliminary to a test. If chlorides are present, a U-tube containing pumice soaked in $CuSO_4$ solution and dried white must be interposed in the train.

Fluorine in Combustible Gases. Meslaus (*Bull. Soc. Chem.*, ix., 109). Organic fluorides, especially the ethers, are exceedingly stable. By burning them in a flask in presence of oxygen they can be converted to HF, which may be absorbed by a solution of KOH previously introduced into the flask. A platinum spiral inside the flask, may be heated by an electric current in order to effect the combustion after the materials have been introduced.

Fluorine in the Ashes of Plants. Ost (*Berichte*, xxvi., 151), describes a method by which, after separation of the Fl as $CaFl_2$ mixed with some impurities, the amount of Fl is determined by the amount of material removed by the HFl therein from a weighed amount of glass. For a full account of the process the original paper should be consulted.

Phosphorus in Iron and Steel, etc. Dudley and Pease (*J. Anal. and*

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App. Chem., vii., 108). Dissolve 1 gramme of steel in a 10 or 12 oz. Erlenmeyer flask by the use of 75 c.c. HNO_3 (sp. gr. 1.13). When solution is complete boil one minute, and then add 10 c.c. "oxidizing" $K_2Mn_2O_8$ solution (12.5 grammes per litre). Boil until the pink color disappears, then add little by little crystals of $FeSO_4$ (free from P), to reduce and redissolve the MnO_2. Avoid adding an excess of $FeSO_4$. Heat the clear solution to 185° F.—add 75 c.c. molybdate solution. Stopper. Shake 50 minutes, let stand 5 minutes to settle, and then filter through a 9 cm. paper. Wash with acid $(NH_4)_2SO_4$ solution, until the washings show no coloration with $(NH_4)_2S$. Dissolve in 30 c.c. of ammonia (1 : 5) running the solution back into the original flask. Wash until a bulk of 150 c.c. is obtained, add 10 c.c. conc. H_2SO_4, and dilute to 200 c.c. Pass the liquid through a Jones reductor (preferably the simplified form). Wash until the bulk of the solution is 400 c.c., and then titrate with standardized $K_2Mn_2O_8$ (2 grammes per litre).

The molybdate solution is made up with 100 grammes MoO_3 dissolved in 400 c.c. strong ammonia (sp. gr. 0.96). After filtering it receives the addition of 1000 c.c. of HNO_3 (sp. gr. 1.20). It should stand at least 24 hours, but had best not be over 10 days old. Keep in the dark.

The acid $(NH_4)_2SO_4$ solution for washing is made by adding 27.5 c.c. strong ammonia to 500 c.c. of water, then 24 c.c. conc. H_2SO_4 and diluting to 1 litre.

The simplified Jones reductor consists of a 12 or 15-inch length of combustion tubing, fitted at the upper end with a cork carrying a funnel. The tube is partly filled with finely divided zinc. At the bottom is a layer of coarse sand having both above and below it perforated platinum discs. The lower cork carries a short tube which passes also through the cork of the vacuum flask.

The original paper must be consulted for directions as to management of the reductor, making and preservation of solutions of permanganate, molybdate, etc.

Carnot (*C. Rend.*, cxvi., 105), 5 grammes of iron or steel, or a smaller amount (1 to 0.5 grammes) of phosphoriferous cast metals, are treated with 40 c.c. of HNO_3 in a porcelain dish covered with an inverted glass funnel. When effervescence is over, add 2 c.c. conc. H_2SO_4 per gramme of metal. Evaporate at a gentle heat with constant stirring. The mass when fairly dry is heated for two hours to 120–125° C., then redissolved in 50 c.c. of boiling water, and the SiO_2 filtered off through asbestos. Adhering MnO_2, etc., may be washed off with conc. HCl, this washing being kept separate from the first filtrate. Dry, ignite off the graphite, and weigh SiO_2 ($\times$ 0.4667 = Si).

To the first filtrate add 1 gramme CrO_3, and boil for thirty minutes. Then add 60 to 80 c.c. of a 5 per cent. MoO_3 solution, and heat to 100° C. for two to three hours. Allow to settle and cool, decant through a filter, and wash with lukewarm water containing a little molybdic solution. Dissolve the precipitate in the flask in 30 c.c. dilute ammonia, dilute with an equal volume of hot water. Rinse the filter with dilute ammonia into the same flask. If any iron remains on the filter, dissolve in HNO_3. Neutralize the ammonia solu-

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tion with HNO_3, keeping the solution below 40° C. When the precipitate begins to reappear, unite the solutions. Keep at 40° for two hours, then filter through a weighed filter, wash with dilute HNO_3, dry and weigh the phospho-molybdate ($\times$ 0.01628 = P).

Campbell (*Jour. Anal. and App. Chem.*, vii., 2), gives results obtained in examining iron ores for phosphorus, the points sought to be elucidated being interference of As, and the amounts of P left in the portion of ores insoluble in HCl. The method used was drying and weighing the phospho-molybdate precipitate. As seemed to have less effect than is usually attributed to that element. In almost every case a small amount of P was found in the portions of the ore undissolved by HCl.

Babbitt (*Trans. Amer. Inst. Min. Eng.*, February, 1893) reports the results of experiments with Emmerton's method:

1. Arsenic, if present, will materially affect the result, unless the temperature is kept down to 25° C.
2. The composition of the precipitate was found to be $(NH_4)_6O_3$, 24 MoO_3, P_2O_5 (1.63 per cent. P).
3. The reduction was effected in a simplified form of reductor. The reduction seems to go to a point intermediate between Mo_2O_3 and $Mo_{12}O_{19}$. The relation of Fe standard of the permanganate to the P standard is 1 c.c. = 0.006436 Fe = 0.0001 P., instead of that given by Emmerton, 1 c.c. = 0.006436 Fe = 0.0001 P.
4. Reduction was complete whether two or twelve minutes' action in the reductor was permitted. With a greater speed (thirty seconds), reduction was incomplete. The reduced solution showed no oxidation after standing for half an hour.
5. *All* P was precipitated by five minutes' shaking at 25° C.

Phosphorus in Steel. Wdowizewski (*Stahl u. Eisen.*, xii., 381), describes a method similar in most details with that of Dudley and Pease up to the point of precipitating of the phospho-molybdate. (HCl is used to remove the MnO_2 resulting from the use of "oxidizing" $K_2Mn_2O_8$ solution). For the determination of the P however, the precipitate is dissolved in excess of standard ammonia solution (1 c.c = 0.03534 per cent. P), and the solution titrated back with standard HCl.

Zimmerman (*Stahl u. Eisen*, xii., 131), describes a similar method, in which the precipitate is finally rinsed into a pycknometer, and its weight found by weighing the apparatus thus charged and referring to a table.

Arsenic and Phosphorus in Iron-ores. J. and H. S. Pattinson (*J. S. C. I.*, xii., 119). Dissolve 3 grammes of the ore in HCl, evaporate to dryness, take up with as little excess of HCl as possible, dilute with hot water to 30–50 c.c., cool, and add gradually a strong solution (500 grammes per litre) of $Na_2S_2O_8$ until the iron is all reduced; boil to expel the most of the SO_2. Keeping the solution at a bulk of 50–60 c.c., after cooling and dilution to something less than 100 c.c. 5 c.c. conc. HCl are added, and then about 0.1 gramme powdered ZnS which precipitates As_2S_3, Cu if present will also be precipitated. The sulphides and SiO_2 are then filtered, washed with warm water, acidulated

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with HCl (5 c.c. in 100). The filtrate is boiled to expel H_2S, diluted with cold water to 200–250 c.c. and Fe_2Cl_6 added in sufficient amount to more than combine with all the P_2O_5 present, warmed to 65–70° C., and precipitated, $CaCO_3$ added until ferric phosphate and hydrate are precipitated. This precipitate filters rapidly. It should be washed with warm (not boiling) water, dissolved in HNO_3 and the P_2O_5 separated by molybdate.

The As_2S_3 may be separated from admixture with the SiO_2 by digestion with $(NH_4)_2S$, oxidizing to H_3AsO_4 and determining as the Mg. compound. For the P, the method used is weighing the phosphomolybdate precipitate. The time necessary for estimation of phosphorus is put at something less than two hours, exclusive of the first evaporation to dryness.

Bone Meal and Similar Products. Hess (*Zts. angew. Chem.*, 1893, 74), finds that it is very difficult to get uniform samples of bone meal, etc. In a 50-grammes sample, on sieving the coarse portion showed 22.08 per cent. P_2O_5, the fine 18.89 per cent.

The method recommended is to treat 5 grammes of a well mixed sample in a Kjeldahl flask of 300 to 350 c.c. capacity with 35 c.c. conc. H_2SO_4 and 0.5 to 1 gramme HgO. Boil to oxidize as in the Kjeldahl operation, cool, dilute, finally bringing to a bulk of 500 c.c. in a graduated flask. Pipette off 200 c.c. after settling for the determination of NH_3 (nitrogen). Take another 50 c.c., mix with 50 c.c. citric acid solution (Märkers) add 20 c.c. magnesia mixture, and determine P_2O_5 as usual.

Silicon in Steels (Drown's Method). Dudley (*Jour. Anal. and App. Chem.*, vii., 5). After dissolving in HNO_3, adding H_2SO_4, and evaporating to fumes and diluting, if the solution is allowed to stand for some time, considerable amounts of SiO_2 are redissolved.

Micro-chemical Test for Sulphur. Emich (*Fres. Zts. Anal. Chem.*, xxiii., 163). A small amount of the substance in fine powder is placed on a microscope slide, moistened with a drop of $CaCl_2$ solution (3 to 25 per cent.), and then subjected to the influence of Br vapors. If S or a sulphide is present $CaSO_4$ forms, and the crystals may be readily detected under the microscope. A long list of substances (59), chiefly minerals, but also including ultramarine, $Na_2S_2O_3$ mustard, etc., is given, in which the test was successfully applied.

Testing Sulphuric Acid for Hypo-nitric. Wilson (*Pharm. Jour. and Trans.*, 1890, 54). To 1 c.c. of the acid add a trace of resorcin, dilute with 5 c.c. of water, and shake; the least trace of hypo-nitric acid gives a yellow coloration.

Estimating Nitrites. Grossman (*Chem. Zeit.*, xvi., 818) finds that on adding dilute H_2SO_4 to a boiling solution of nitrite this reaction occurs: $3\ NaNO_2 + H_2SO_4 = Na_2SO_4 + NaNO_3 + 2\ NO + H_2O$. By using normal or fractional normal H_2SO_4 the determination can be effected. The acid should be standardized against nitrite of known purity. If the commercial sample tested contains free or carbonated

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alkali, this should be determined by a titration in the cold and a correction made.

Oxygen in Lead. Lunge and Schmid (*Zts. f. Anorg. Chem.*, 1892, II., 451). The method pursued is to pass H through the molten lead and weigh the water produced. The H is purified by passage through NaOH solution, then through solution of PbO in KOH, then through $AgNO_3$, then conc. H_2SO_4, then through a tube containing platinized asbestos, followed by H_2SO_4 and U-tubes containing P_2O_5, and after this purification it is passed through the lead, kept melted in a hard glass tube, and the resulting water collected for weighing in a U-tube containing P_2O_5.

Constituents of Salt Brines J. and S. Wiernik (*Zts. angew. Chem.*, 1893, 43). Considering only the chief constituents NaCl, $MgCl_2$, $CaSO_4$, $MgSO_4$ and Na_2SO_4, three different rules for the grouping of the amounts of elements and acid radicals found are given.

1. Fresenius, *Quant. Anal.*, 6th ed., II., 290. Calculate SO_3 to CaO, then to MgO, any excess of SO_3 to be calculated to Na_2SO_4, any excess of MgO calculate to $MgCl_2$. This the authors call the "$MgSO_4$ rule."

2. Böckmann's rule (*Chem. Techn. Untersuch'n*, 3d ed., I., 294). Calculate all MgO to $MgCl_2$, the CaO with SO_3, any excess of SO_3 as Na_2SO_4; "the $MgCl_2$ rule."

3. A rule in vogue with some French salt boilers called "the halving rule." Calculate half the MgO as $MgCl_2$, the other half as $MgSO_4$. Reckon SO_3 remaining to CaO, and if any excess of SO_3 remains calculate to Na_2SO_4.

The last is more arbitrary than the first two, but seems to give good results. The authors recommend evaporating a measured quantity of the water to dryness, extracting with alcohol, and examining the residue and alcohol extract separately.

METALLURGY, BY JOSEPH STRUTHERS.

THE ELECTRIC TELEPHONE PYROMETER OF HARTMANN AND BRAUN.—The pyrometer consists of a platinum spiral, whose relative electrical resistance and the variation with the increase of temperautre has been accurately determined. The spiral, placed in the lower part of an iron tube serving as a shield, extends as far as the flange, and all below this flange is introduced into the furnace.

FIG. 1.

$\frac{1}{10}$ actual size.

The ends of the spiral are joined to the binding posts (P P, Fig. 1) by thick conductors of platinum. The changes in resistance and, con-

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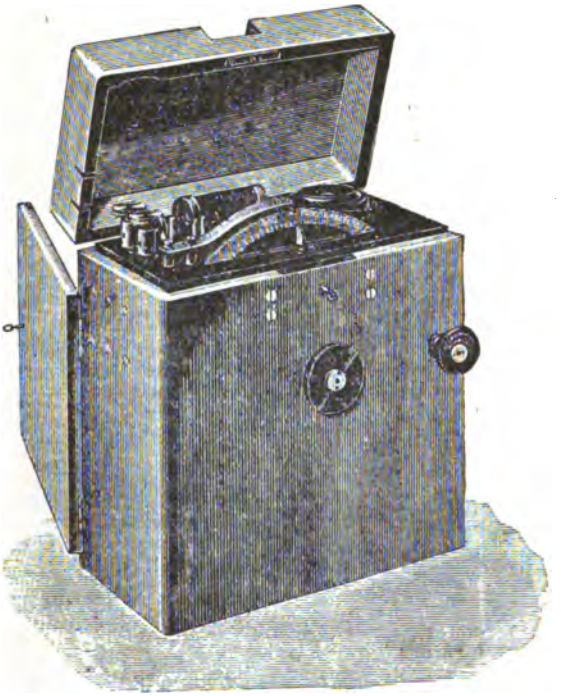
sequently, the temperature are read off on a Wheatstone bridge, and two of the three known resistances are altered until their ratio is the same as that between the pyrometer and the third resistance.

This equilibrium can be made apparent by the use of a galvanometer and a small battery. If the former is used, there should be no deflection.

If the apparatus is exposed to jarring, making it difficult to read a galvanometer, this can be replaced by a telephone, and a small induction coil furnishes the necessary alternating current.

FIG. 2.



$\frac{1}{8}$ actual size.

An apparatus of this kind is shown in Fig. 2. The battery is placed in a compartment at the back, and is used to run the induction coil, which is shown in the diagram.

The wire connections and some resistance coils are placed inside the box. The two variable resistances, previously mentioned, are composed of a single wire, wound on the periphery of the graduated disc, partly visible in the illustration, and this wire is divided into two parts by a small contact roller, fastened to a vibrating arm. The proportion between these two parts depends upon the resistance introduced, and the movable graduated disc is adjusted by means of the large milled head, seen on the front of the box. The small milled head, seen at the right, is used as a contact key.

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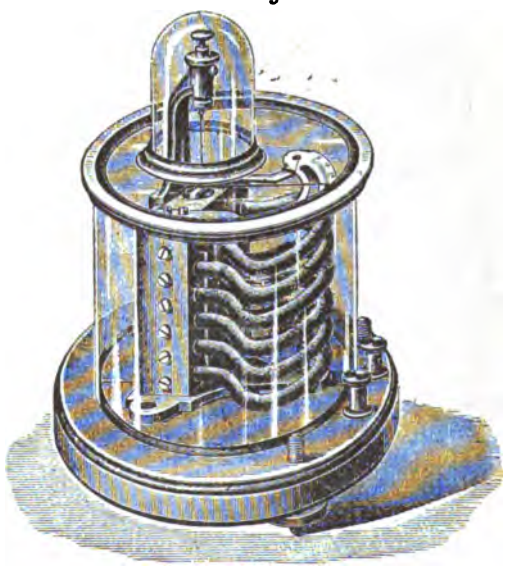
The telephone is seen at the right, on the top of the box, and is connected to the apparatus by means of a flexible cord. The pyrometer is joined to the apparatus by two wires, which are fastened to the two large binding posts, seen on the left.

In order to make a determination the current is turned on, the induction coil started, and the telephone applied to the ear. If a sound is heard, which is generally the case, the large milled head is turned in one or the other direction until the sound ceases.

The figure on the circular scale, opposite a stationary pointer, seen in front, gives directly the temperature sought in Celsius degrees.

The galvanometer used with the apparatus is shown in Fig. 3.

FIG. 3.



¼ actual size.

It is of the Deprez and D'Arsonval type, and is convenient because it is portable, quickly set up and suitable for this kind of work.

This pyrometer can be used for temperatures as high as 1500°, but if the temperature is over 1000°, the iron tube or case should be replaced by one of platinum.

The instrument can then be used as a Telepyrometer, and the measuring apparatus may be set up in an office or other convenient place.

In regard to the durability of the apparatus, it is claimed that the spiral, after many years' use, does not vary in its electrical resistance or temperature co-efficient, and that under the same circumstances it yields comparable results.—Translated from *Stahl und Eisen*, July, 1892.

CALCULATION OF FLAME TEMPERATURES.—By E. Blass, (*Iron*), February, 3, 1893.—The author records results of extended experiments on

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heat attainable by gas flames. He was induced to undertake these investigations from the fact that platinum can be brought to a welding heat, but cannot be melted in a crucible furnace by combustion of cold gas with cold air, which should, according to the old formulas, give a sensible temperature of 2.650° C., which is far above the melting point of the metal (1.775° C., as determined by Violle). This difference is due to the assumption that the specific heats of the products of combustion, H_2O and CO_2, are constant, whereas these values actually change very rapidily with increased temperature in both gases, the expression of their mean value being (Le Chatelier):

CO^2. $C^p = 0.188 + 0.000273t - 0.0000000537t^2$.
H_2O. $C^p = 0.420 + 0.000364t$.

Calculated in this manner the temperature attainable by burning water gas with air is approximately 1700°, a result sufficiently near to the value obtained by Violle's direct experiments to establish the probable correctness of the Le Chatelier formula. In order to test this point more completely, a set of experiments have been carried out by the German Iron Smelters' Society and the European Water Gas Company with water gas supplied by Messrs. Schultz, Knaudt & Co., a fuel selected as being of simple and uniform composition. The apparatus consisted of a four-tuyere crucible melting furnace, containing an empty steel melting crucible, with four tubes perforating the sides at right angles to each other. Three of these tubes contained pyrometers, while the fourth took off a portion of the products of combustion to a condenser and gas meter, in order to determine its composition. The gas supply was measured by two gas meters of 50 and 100 cubic metres capacity per hour respectively, and the air supplied by Root's blowers driven by variable speed pulleys, each step corresponding to a difference of 100 cubic metres per hour.

The composition of furnace gases was educed at short intervals by analyses of samples taken directly from the furnace, as well as from the portion collected through fourth tube by the meter. These analyses, although conducted with extreme care, showed that the relative proportion of H_2O to CO_2 was subject to variation of rather wide limits, and that gases do not mix as rapidly and uniformly as they are generally supposed to do.

The pyrometers used were: 1. Wiborgh air thermometer, which can be used up to 1200° C. 2. Le Chatelier's thermo-electric pyrometer, available up to the melting point of platinum. 3. Hartmann & Braun's telephone pyrometer. Besides these, Siemens's calorimetric pyrometer, Seeger's normal clay cones, Ducretel's optical pyrometer, and Princep's pyrometic alloys of gold and platinum (supplied by the Frankfurt Gold and Silver Refinery) were used on different occasions.

The air thermometer of Wiborgh, though most exact in principle, was not very satisfactory, two different instruments giving dissimilar indications without it being possible to discover the cause of the differing results. The telephone pyrometer was found to be very convenient to work, but was destroyed early in the tests.

The Chatelier pyrometer is easy to handle, the only objections raised

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to its use being the alteration in time of the thermo couple and the fact that the galvanometer is so sensitive to vibrations that it can scarcely be used in any place where machinery is at work.

The Ducretel polariscope is scarcely to be regarded as a pyrometer, as no correct measure of temperature could be obtained from it, although in experienced hands it may be of value in comparing different sources of heat. Considerable experience and sensitiveness of the observer to slight changes of color are essential features. Princep's alloys gave results agreeing very well with the Le Chatelier pyrometer.

When the apparatus was finally gotten in good working order experiments were made, each extending over a period of eight to ten hours. The results are tabulated as follows:

	Gas in excess.		Air in excess.		Gas and air in theoretical proportions.	
	I.	II.	III.	IV.	V.	VI.
Temperature.....	Gas : air = 1 : 0.18	Gas : air = 1 : 0.714	Gas : air = 1 : 9.79	Gas : air = 1 : 4.18	Gas and air cold.	Gas cold; air 840°.
Observed.....	425	1170	655	1218	>1775	>1775
Calculated by new formula.....	409	1173	688	1235	1690	1947
Calculated by old formula.....	521	1560	747	1890	2630	2916

In the fifth experiment, with gas and air in proportions, for theoretically perfect combustion, the loop of the thermo pile in the platinum rhodium alloy was twice melted, but a platinum wire of 1 millimetre diameter and a gold platinum alloy, No. 24, whose reputed melting point is 1690°, showed only superficial fusion.

The sixth experiment was made by Mr. Dicke, at Mr. Pintsch's works, the gas being burned with air-heated to 840° C. In this case the platinum was completely melted, the temperature realized being more than sufficient for the fusion of the best Dahlhausen firebricks and could only be resisted by a magnesite lining to the furnace. A point of interest in experiment II. is the circumstance that both copper and iron were oxidized in the flame, although the latter contained about 40 per cent. of reducing gases (carbonic oxide and hydrogen). It is evident, therefore, to obtain a flame in which iron will not oxidize, the gas must be present in large excess, as in I., where, however, the heat realized is too low for any but limited purposes. The author suggests that possibly a non-oxidizing white heat, or 1400° might be realized by the conditions of experiment I. if both gas and air were brought to a temperature of 1000° before combustion.

In order to form an idea of the temperature attainable by the combustion of different mixtures of gases, the author has compiled the following table of theoretical temperatures. The fuel is assumed to be chemically pure:

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	Gas and air cold.	Gas cold; air 1000°.	Gas 1000°; air 1000°.
Producer-gas ⅓ vol. CO + ⅔ vol. N.	1450	1750	2160
Water gas ½ vol. CO ½ vol. H.....	1875	2270	2400
H.....	1650	1970	2140
CO.....	1955	2390	2570

When the above value for theoretical water gas, 1875° C., is compared with the 1690° C. found by experiment, the difference is only 185°, or about 10 per cent, whereas the difference between 2160°, calculated for producer-gas, and 1500°, observed by Le Chatelier as the maximum heat of the Siemen's furnace, is 660° C. and represents nearly 30 per cent. The reason for this is to be sought not in the non-development of the calorific value of the fuel in practice, but in retarded combustion, owing to the gradual mixture of air and gas, so that the heat is distributed over a large area, with a corresponding diminution of maximum intensity, whereas when gas and air are burned under the conditions of the experiments, both being supplied under pressure, combination is rapidly effected with the result of producing a focus of intense temperature.

LEAD.—Use of Burnt Lime in Lead Blast-Furnaces. S. E. Bretherton (*E. and M. J.*), March 4, 1893, has used burnt lime for over eight years. Its advantages are: 1. No crushing or sledging; 2. Furnace keeps open better, slag cleaner and less wall accretion; 3. More ore can be smelted with same labor and fuel than can be smelted with lime rock, at less cost. Suppose a thousand pound charge required 150 pounds CaO net. By using a limestone flux of 53.86 per cent. CaO and 1 per cent. SiO_2 (52 per cent. CaO net), it would require the following amount: 288 pounds of flux, 712 pounds of ore, total, 1000 pounds. If the limestone is burnt, its composition becomes CaO 96.72 per cent., SiO_2 2 per cent., with net CaO at 93 per cent. With this material the thousand pound charge would then be 839 pounds of ore and 161 pounds of burnt limestone. In this manner 127 pounds more of ore can be treated with same labor and fuel, and in addition the limestone does not require crushing.

COPPER.—The Electrolytic Refining of Copper. Translated from the French of M. Hippolyte Fontaine. Result of researches made by M. Kiliani, of Munich, on action of copper oxide and sulphide, silver, gold, platinum, bismuth, tin, arsenic, antimony, lead, iron, nickel, zinc and cobalt.—*Eng. and Min. Jour.*, March 11, 1893.

PLATINUM.—The Future of Platinum. Discusses production and uses.—*Eng. and Min. Jour.*, March 4, 1893.

FUELS.—An Investigation of Coals for Making Coke in the Semet-Solvay Ovens, with the Recovery of Ammonia and Tar, and Remarks on the Sources of Ammonia.—By J. D. Pennock.—Advance sheets of the Montreal Meeting, February, 1893, of the American Institute of Mining Engineers.

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FUELS.—Development and Condition of the Coke Industry by the Utilization of Bi-products.—B. Leistikow. Descriptive article giving illustrations of the Otto-Hoffmann oven and condensing plants.—*Jour. Frank. Inst.*, January, 1893.

BLAST HEATING —Hot-Blast Stoves. Discussion (continued) of Mr. Coffin's paper on the Hugh Kennedy Hot-Blast Stove.—Advance sheets of the Montreal Meeting, February, 1893, of the American Institute of Mining Engineers.

BLAST-FURNACE.—Roasting and Smelting Plant at Londonderry Iron Works.—By R. G. Leckie. Illustrated description of roasting and blast-furnaces.—*Transactions* of the Mining Society of Nova Scotia, January, 1893, and abstract of same in *Amer. Manuf.*, March 10, 1893.

BLAST-FURNACE PRACTICE.—Titaniferous Ores in the Blast Furnace.—By Auguste J. Rossi. Description of process as carried on by the Adirondack Iron and Steel Co. in 1848–52, and general discussion of the use of such ores in modern practice, supplemented by experimental tests in small blast-furnaces.—Advance sheets of the Montreal Meeting, February, 1893, of the American Institute of Mining Engineers.

BLAST-FURNACE CONSTRUCTION.—Abstract of M. Boivin's paper, in *Comptes Rendus*, on Construction of Hearth at Firminy, The hearth is enclosed in segmental annealed steel rings, 3 feet 3 inches long, 5¾ inches thick, 19 inches high, and total height of 8½ feet, extending below hearth level.—*Amer. Manuf.*, March 17, 1893.

CAST IRON.—Non-Uniformity of Iron Made in One Cast.—By Morton Stevens. Results of tests show that the silicon ran high in beds near the middle of the cast. Analyses quoted.—*Amer. Manuf.*, March 17, 1893.

CAST IRON. CUPOLA PRACTICE.—The Casting of a Large Steam Cylinder. An illustrated description of the casting of a 48,000 pound cylinder at the Wheeler Condenser and Engineering Works, at Carteret, N. J., on January 26, 1893. The size of this cylinder is 95 inches internal diameter and about 14 feet high.—*Scientific American*, March 11, 1893.

PIG-IRON.—Locations for Pig-Iron Production.—John Birkinbine, *Engineering Magazine*, March, 1893.

PIG-IRON.—Production of Pig-Iron in the United Kingdom for 1892:

	Tons.
Forge and Foundry Pig-Iron,	3,518,296
Hematite Pig-Iron,	2,684,484
Spiegel and Ferro,	152,446
Basic Pig-Iron,	261,664
Total,	6,616,890

—*Amer. Manuf.*, March 24, 1893.

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STEEL.—Bessemer Steel Production of 1892, from Swank's Reports:

States.	Tons of Ingots.
Pennsylvania,	2,388,012
Illinois,	880,234
Ohio,	411,982
Other States,	480,744
	4,160,972
Clapp-Griffiths,	67,526

—*Amer. Manuf.*, March 10, 1893.

STEEL.—Production of Steel in the United Kingdom for 1892:

Bessemer Steel Ingots:

	Tons.
Acid,	1,202,027
Basic,	298,783
Total,	1,500,810
Bessemer Steel Rails,	535,836

Number of Converters:

	Acid.	Basic.
Operative,	45	17
Inoperative,	33	11
Total,	78	28

—*Amer. Manuf.*, March 24, 1893.

STEEL.—Steel Making in the South.—Editorial article on steel manufacture in the Southern States; gives statistics showing the great advance in recent years on production of coke pig-iron and the stationary production of charcoal iron. Criticizes the South for making no advance in the manufacture of finished iron and steel goods.—*Eng. and Min. Jour.*, March 18, 1893.

STEEL.—Observations on the Relations Between the Chemical Constitution and Physical Character of Steel.—William R. Webster. Record of investigation on 500 samples of basic Bessemer and basic open-hearth steel of constant carbon limits and variable amounts of manganese and phosphorus.—Advance sheets of the Montreal Meeting, February, 1893, of the American Institute of Mining Engineers.

STEEL. PIT PRACTICE.—Improved Steel Casting Ladle and Carriage. Short description, with illustration of ladle manufactured at Preston, England, in use at several steel works.—Abstract from "Industries," *Amer. Manuf.*, March 17, 1893.

STEEL. PIT PRACTICE.—Ingot Moulds. By James Riley.—A paper read before the West of Scotland Iron and Steel Institute, February 17, 1892. Advocates the use of the ordinary hollow pyramidal moulds in an inverted position with larger end up, and claims better results from rolling ingots cast in this manner.—*London Iron*, February 24, 1893.

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STEEL CASTINGS.—By Sergius Kern, M. E., St. Petersburg. Describes method and mixture for Russian practice, also quotes chemical analyses and mechanical tests on open-hearth steel.—*Chem. News*, March 3, 1893, *Amer. Manuf.*, March 24, 1893.

STEEL. MANGANESE STEEL.—By Henry M. Howe. Description of preparation and discussion of its physical properties, giving tabular statistics of the comparative effect of varying amounts of manganese.—*Jour. Franklin Inst.*, February, 1893, and March, 1893.

STEEL. ANALYSIS.—Method of Determining Phosphorus in Steel.—C. B. Dudley and F. N. Pease. A descriptive article with illustration of mechanical shaker used in the method.—*Jour. Anal. and App. Chem.*, February, 1893.

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BOOK REVIEWS.

ALTERNATING CURRENTS OF ELECTRICITY: THEIR GENERATION, MEASUREMENT, DISTRIBUTION AND APPLICATION. By Gisbert Kapp, C.E. With an introduction by Wm. Stanley, Jr., 1893. The W. J. Johnston Co, Ltd., 41 Park Row, New York City. Price $1.00.

In this work the principles of alternating currents are developed in so simple a manner that it can be followed by any reader who has mastered the most elementary principles of electricity; and the various applications are sketched in a broad and instructive way that clears away the many difficulties with which they were supposed to be surrounded. The few mathematical formulæ in the book are confined to appendices.

The first four chapters are devoted to the explanation of alternating currents and of the methods of measuring them, and the three succeeding ones are on the principles and design of alternating current generators and transformers. Chapter VIII. is on central stations which employ alternating current systems and Chapter IX. on the parallel coupling of alternators.

The remaining chapters treat of various forms of alternating motors, especial attention being paid to the explanation and discussion of polyphase motors.

The treatment throughout is practical, and the data and discussion on the design and construction of apparatus will be found valuable to the less advanced electrician and designer.

In his introduction, Mr. Stanley refers his readers to papers of Dobowolsky, Kelly and Steinmetz, for information on points relating to the variation of intensity of the rotary magnetic fields produced by polyphase currents. It is rather surprising to notice that Mr. Stanley is so ignorant of the fact that Dr. Pupin, in his paper "On Polyphasal Generators" (*Transactions of the American Institute of Electrical Engineers*, December 16, 1891), was the first to point out certain fallacies in Dobowolsky's reasoning, with reference to the points just mentioned, and that, too, several months before the authorities which he cites published a word about this matter. M. I. P.

LOGARITHMIC TABLES. By George William Jones. Fourth edition. 8vo., pp. 160, $1.00. Macmillan & Co., London, and G. W. Jones, Ithaca, N. Y.

The essentials of a good logarithmic table are two in number: First, accuracy, and second, convenient arrangement. The continued publication of new sets of tables is therefore to be deprecated. First, because it is always extremely difficult to insure complete accuracy of tabular printed matter, and secondly, because a book, which is other than a mere copy of older works, is certain to have an inconvenient arrangement; for convenience depends upon custom, and now that we have all become accustomed to an accepted arrangement of tables, any very new departure is necessarily troublesome, and, therefore, inconvenient.

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With regard to the numerical accuracy of the book under discussion, it is, of course, impossible to make any definite statement. At all events, the author admits the probability of error, for he offers to pay one dollar for each mistake discovered. It is not likely that any one will find it worth while to hunt for errors at this rate. In the trigonometric tables we find the natural functions and their logarithms arranged in parallel columns of the same table. Probably Professor Jones has accustomed himself to this, but we venture to doubt whether most practical computers would find it to their advantage to do likewise. The interval of the argument is one minute of arc throughout the entire table, and there are no tables of proportional parts. In addition to the usual tables, the volume contains primes to 20,000, and 2000 quarter squares. Interpolation coefficients, probability tables, and "constants" are also to be found in it.

HAROLD JACOBY.

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BULLETIN OF ALUMNI AND COLLEGE NEWS.

Notices have been sent to all graduates calling attention to a dinner of the Alumni of the School of Mines, to be given under the auspices of the Alumni Association, on Thursday, May 11, 1893. Further notice is to be given of final arrangements.

The trustees have appointed a committee, consisting of Prof. Van Amringe, Secretary of the Faculty of Arts, and John B. Pine, Clerk of the Board, to prepare a new edition of the General Catalogue of Officers and Alumni, to be issued in 1894. The last edition, which was prepared by Prof. Van Amringe, contains a very full list of the names of the alumni; but it is proposed, in the forthcoming edition, to include also the addresses of the alumni, their professions, their degrees, the colleges by which the same were conferred and their titles, judicial, military, clerical or other. To secure this information will be a task of considerable magnitude, which cannot be accomplished without the assistance and co-operation of the alumni. It will, at least, be possible for every graduate who reads this to forward to the committee his own name, with the name of the school from which he graduated, his class, present address, his degree and official title, if any.

All communications should be addressed to the Committee on the General Catalogue, Columbia College.

On March 21, 1893, the University Council, under Chapter XVII., Section 1 of the Revised Statutes, awarded the following Fellowships:

REAPPOINTMENTS.—H. J. Burchell, Jr., A.B., Columbia College, 1892. Subject, Latin; J. A. McLean, A.B., University College, Toronto, 1892, Comparative Jurisprudence; J. D. Rogers, A.B., Hamilton College, 1889, Greek; S. H. Rowe, A.B., Yale College, 1890, Pedagogy; J. K. Small, A.B., Franklin and Marshall College, 1892, Botany; Francis Walker, B.S., Massachusetts Institute of Technology, 1892, Economics; Asa Wynkoop, A.B., Rutgers College, 1887, Philosophy.

NEW APPOINTMENTS.—George H. Batchelor, A.B., Indiana University, 1892, Finance; L. G. Bugbee, A.B., University of Texas, 1892, History; C. E. Chadsey, A.B., Leland Stanford, Junior University, 1892, Finance and History; Herman S. Davis, A.B., Princeton, 1892, Astronomy; Emery Allison Drake, A.B., St. Xavier College, Cincinnati, 1886, Anglo-Saxon; Henry C. Emery, A.B., Bowdoin College, 1892, Social Science; W. J. Hannah, A.B., University of Indiana, 1892, Social Science; Harwood Huntington, A.B., Trinity College, 1884, Chemistry; Caspar Levias, Columbia College, 1893, Oriental Languages; George H. Ling, University of Toronto, 1893, Mathematics; William D. Matthew, Columbia College, 1893, Geology; Albert P. Mathews, B. S., Massachusetts Institute of Technology, 1892, Biology; R. A. Millikan, A.B, Oberlin College, 1891, Physics; Heinrich Ries, Ph.B., Columbia College, 1892, Mineralogy; William R. Shepherd, Columbia College, 1893, History; Arthur B. Simonds, A.B., Harvard University,

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1891, Romance Languages; Selden L. Whitcomb, A.B., Iowa College, 1887, Literature.

Edward Ferris Weekes, Class of '89, School of Mines, died on March 26th, after a short illness. He was born in Brooklyn, January 23, 1869, and was a brother of Chas. Parker Weekes, who was accidentally drowned while on a canoeing trip last spring.

Mr. Weekes served as president of his class during the freshman year, was a member of the class crew, and throughout his entire course took a prominent and active part in class and college matters. Soon after graduating he entered the Department of Public Works in the City of Brooklyn as Assistant Engineer, and shortly after assumed complete charge of the extensive contracts for granite repaving. He was still connected with the department at the time of his death.

DEPARTMENT OF PHYSICS.

During the current year many new and instructive experiments have been introduced into the courses, and more will be added next autumn. An additional room, fronting on Forty-Ninth Street, gives a much-needed place for research and post-graduate work, and now the whole upper floor of Hamilton Hall is occupied by the Physical Department.

At present the laboratory is able to give its 110 students all the usual facilities, as well as others which are believed to be unique and of especial value. The changes in the courses and the normal growth will throw over two hundred students into the laboratory next fall, with a corresponding increase of attendance on lectures, a figure not exceeded, if reached, by any other physical department in the world.

DEPARTMENT OF MINERALOGY AND METALLURGY.

A volunteer class has been formed in this department from second year students to prepare in optical mineralogy and crystallography for work next year in lithology under the geological department. It is proposed hereafter to allot more hours to mineralogy in the first and second years for students in mining engineering, metallurgy and geology, so that time may be secured in the second term of the second year for work in microscopic mineralogy and lithology under the two departments. The order of instruction will then be Blowpipe Analysis, Crystallography, Descriptive and Determinative Mineralogy, Optical Mineralogy and Lithology.

Mr. Whitlock has painted a most artistic water color chart of the reactions of the volatile elements upon charcoal and plaster with and without fluxes. This is to be exhibited with other material incidental to determination of minerals under the Department of Mines and Mining.

A complete card index of the literature of mineralogy and crystallography is in course of preparation.

The following new or rare species have been added to the collection: Bobierrite, Glasurite, Monzonite, Offretite, Pinakiolite, Edelite, Svabite, as well as about three hundred handsome specimens of minerals previously represented.

The department received one of the University Fellows, Mr. Heinrich Ries, of '92, who will take for his major subject the amphiboles and pyroxenes of New York State.

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Mr. Luquer, Tutor in Mineralogy, is to superintend the arrangement of the scientific mineral exhibit of the University of the State of New York at the World's Fair.

Mr. James E. Talmage, of the Deseret Museum, Salt Lake City, has sent to the School of Mines 1000 pounds of crystals of selenite from the cave at South Wash, Utah. One of these has been described by Prof. Moses in *Science*, April 28th, and the others will be carefully examined and described.

Specimens of sodalite presented by T. D. Ledyard, from two new localities, are now being examined by Mr. Luquer and Mr. Volckening.

The department acknowledges the following gifts:

G. F. Kunz, three anthophyllites and platinum sands and concentrates from the Ural, with pictures of the platinum mines.

J. E. Talmage, two crystals of selenite, one 20 and one 28 inches long, from Utah.

E. Cumenge, large number of crystals of the new mineral boleite.

A. L. Walker, specimen of atacamite from the Old Dominion mine.

J. H. Erby, erythrite from French creek.

Harbeson and Walker, five carbon bricks.

A. M. Hoyt, five cast-iron art castings from the Urals.

Tiffany & Co., one " " " "

G. F. Kunz, two " " " "

W. H. Radford, Class of '71, collection illustrating the hydraulic mining deposits of California.

W. McConway, twenty-five specimens illustrating the manufacture of malleable iron castings.

DEPARTMENT OF GEOLOGY.

The evening of March 27th was devoted by the New York Academy of Sciences, with whom the Scientific Alliance of New York City joined, to a memorial meeting for Professor Newberry. The chief address was delivered by Professor H. L. Fairchild, of Rochester. Letters were read from college-mates of Dr. Newberry and from Professor Van Amringe, Professor Edward Orton, State Geologist of Ohio, and Sir Archibald Geikie, Director of the Geological Survey of Great Britain. Remarks were also made by various friends. The proceedings will be published in the *Transactions* of the academy.

The department received one fellow, W. D. Matthew, at the recent elections. Mr. Matthew's thesis-subject will be an area of old plutonic rocks near St. John, N. B.

Professor Kemp will leave about June 1st to begin the regular summer field-work of the department in the eastern Adirondacks. June and September will be devoted to this work. For the earlier month the party will consist also of Matthew, '93; Pomeroy, '93, and White, '94. We also hope to have Dr. C. H. Smyth, Jr. ('88), now in charge of the geological department at Hamilton College, with us for a time. The *personnel* of the party for September is not yet completed.

Professor Kemp will join the class of mining engineers the last week of their stay in the coal regions, and will devote a week to field-work with the class. Dips and strikes will be recorded, specimens gathered, and the necessary data accumulated for a geological map with sections of a limited area.

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Mr. Hollick will be in the field this summer in further work upon the eastern exposures of the Cretaceous, upon Long Island and Martha's Vineyard. The collection of palæobotanical material will be one of his chief objects, and for this both the Cretaceous and the later formations, including the glacial clays, will be searched.

In connection with the department of mineralogy opportunity for a volunteer class in microscopic petrography will be offered the third-year mining engineers next year. The endeavor is being made to find a place for required work of this nature.

The fourth-year class in economic geology has been recently favored by two lectures from Dr. W. P. Jenney, '68, upon the zinc and lead deposits of the Mississippi Valley. Dr. Jenney has been studying them for the last three years under the auspices of the U. S. Geological Survey.

The department has lately been favored with several gifts and loans of photographs of mining districts, notably from Mr. E. E. Olcott, '74, and Mr. T. J. Jones, '90. Any such gifts or loans are extremely acceptable and are used for lantern-slides with the classes.

Summer School of Surveying.

The Summer School of Surveying anticipates the largest attendance in its history for the ensuing season. Some one hundred students in all are expected. This is partly owing to larger classes than in previous years, and partly to the fourth-year class going to camp for the first time this summer.

The fourth-year students are to devote their time exclusively to railroad surveying, and it is expected that a more practical training will be possible than by former arrangements.

A line of road will be completely surveyed by each squad of a length sufficient to bring genuine problems of location before the students.

The arrangements with the United States Geological Survey, whereby the third-year students had the opportunity at the end of their regular course in surveying to join a topographical party in the field for a week or more worked very satisfactorily last season, and will probably be continued.

The School of Surveying will be in charge of Prof. Greenleaf as formerly.

Department of Astronomy.

Prof. Rees has received a generous donation from Rutherfurd Stuyvesant for the purpose of securing a Repsold macro-micrometer. This instrument has been ordered, and will be delivered in about eighteen months. The makers are the renowned Repsolds of Hamburg.

The instrument will be used in measuring the photographed plates made by Rutherfurd, and which he did not measure. It will also be employed in measuring new plates. Other observatories may send plates here to be measured.

The long expected zenith telescope by Wanschaff, of Berlin, came to hand in the latter part of March. It is now mounted in the little observatory at 116th Street and Tenth Avenue. Work has been begun. The purpose of the observations is twofold; to determine in connection with

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the Royal Observatory at Naples (M. Fegola, director), the "variation of latitude" and the "constant of aberration."

The Italian instrument, which is in all respects like the Columbia zenith telescope, will be ready for work about May 1st. The observatory, in connection with the New York Academy of Sciences, has published Mr. Jacoby's reductions of the Rutherfurd photographic measures of the stars about β Cygni, and the parallaxes of μ and θ Cassiopeiæ and of β Cygni as determined from Rutherfurd's observations.

DEPARTMENT OF BIOLOGY.

The Thursday evening lectures conducted by different members of the department throughout the year have been successful in point of attendance, and it is proposed to continue them next year, when they will be given upon Friday evening, as Thursday is found to be inconvenient for many of the students in the college and School of Mines. Arrangements are being made to publish the courses which have been given this winter, in a uniform manner, and it is found that the large charts which were prepared at considerable expense expressly for the lectures, can be reduced by photography, and make admirable illustrations for the text. The plan of these lectures is, to give a semi-popular presentation of recent discoveries in different branches of biology, and to bring the subject up to date—that is, to give more recent information than is found outside of the various scientific periodicals. It is believed, therefore, that the lectures will attract increasing interest and become a permanent feature of the work of the Biological Department.

The investigations going on in the laboratory are mainly as follows:

Dr. Osborn has been mainly engaged upon the new collections of fossil vertebrates in the American Museum of Natural History, and has recently published a number of papers in the bulletins of the museum, and several popular articles in *Nature* and the *American Naturalist.*

Prof. Wilson is completing his paper upon the early development of the Lancelet (Amphioxus), and will conclude his paper with a description of the bearing of the experiments which he has carried on in the early stages of development of the Lancelet upon current theories of heredity. By shaking the embryo in the two-, four-, six- and eight-celled stages respectively, he has succeeded in producing out of a single ovum from two to eight individuals, decreasing in size proportionately, yet each presenting all the characteristics of the complete individual in reduced form.

Dr. Dean has been working mainly upon the additions to the Newberry collection of fossil fishes, and has discovered a great many points of the greatest interest in the collection. These have been partly put together for publication in a coming number of the *Journal of Morphology*, in a paper relating especially to the origin of the fins in Cladodus, and a large memoir is in preparation upon the whole collection, which will probably be offered to the New York Academy of Sciences.

Mr. Willey has been engaged upon the ancestry of the primitive Vertebrates or Protochordata, and their relations to the Ascidians and other primitive groups. The first part of a series of papers has been published in the *Quarterly Journal of Microscopical Science*, and will be reprinted in the forthcoming studies from the Biological Department.

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During the summer eight members of the college will go to the Marine Biological Station at Woods' Holl, Massachusetts, including four of the instructors and a number of students, for purposes of study and original investigation.

The laboratory is in disorder owing to the introduction of the electric lighting system, which will be a very great improvement when it is completed. The cases for the exhibition of the Naples and Bahamas collections, the latter made by Dr. Northrop, School of Mines, '90, are also at last in place, so that in a few weeks the entire arrangement of the laboratory, which has caused great inconvenience to the instruction will be completed in the present quarters.

ELECTRICAL DEPARTMENT.

Laboratory work has been carried on during the second term with even more than ordinary vigor, partially because the third year men had reached that stage in their electrical course where practical testing of direct-current dynamos and motors requires their presence in the laboratory almost every day of the week, and partly because the men of the graduating class were busily engaged in finishing the experimental part of their graduation theses

Most of the men of the graduating class have already obtained very interesting results, of considerable practical importance. Their investigations have reference to high-voltage insulation tests, efficiency of motor transformers, and of alternating-current motors. The laboratory facilities had therefore to be considerably increased to enable these men to carry out their work with credit to themselves and to the department.

It is a very encouraging sign to observe that a keen spirit of original inquiry exists even among the younger students of the department. It is needless to observe that with such students lecture-room work is a great pleasure to the instructors.

Professor Crocker's lectures to the students of the various engineering departments on the most important features of practical electrical engineering seem to be very popular with the students, judging from the attendance. These lectures are the first attempt to supply what was long ago felt at Columbia College to be in strong demand in all engineering and other scientific professions. It is, however, a very difficult problem to design an elementary course on so large a subject which would be neither too broad nor too narrow for that class of students who wish to gain a general and yet perfectly definite knowledge of the most essential features of practical electrical engineering. Professor Crocker, himself a graduate of the School of Mines, is eminently fitted to design such a course for the School of Mines engineering students, and it is a great pleasure to all friends of the School of Mines to observe that these lectures are so well appreciated by the students. Mr. Freedman has been of great assistance to Professor Crocker in this difficult enterprise.

Professor Pupin is publishing a series of articles in the *American Journal of Science* on "Electrical Oscillations of Low Frequency and Their Resonance." The first article appeared in the April, the second in the May and the third article will appear in the June number. He has also a paper on "Resonance Transformers" for the annual meeting in May

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of the American Institute of Electrical Engineers, and is preparing a paper for the Electrical World's Congress in Chicago.

The main results of Dr. Pupin's investigations may be summed up as follows:

1. Every electrical circuit has a natural period just like a pendulum. This period depends on the co-efficient of self induction and the capacity of the circuit, and *on nothing else.*

2. Every electrical circuit can be tuned just like a musical instrument by properly varying its capacity and self-induction.

3. The electrical flow in circuits is maximum when the periodically varying impressed electromotive force and the circuit are in resonance.

4. When the impressed electromotive force is complex harmonic, then the flow can be made to follow a simple harmonic law by bringing the circuit in resonance with any one of the harmonic components of the complex harmonic electromotive force.

5. In mutually inductive circuits resonance of one circuit does not necessarily interfere with the resonance in any other.

6. Resonance is usually accompanied by a large rise of potential in the condenser.

7. Electrical resonance offers a very simple and very effective means of transforming low into high potentials and *vice versa.*

8. Electrical resonance affords simple and very delicate methods to study the working of alternating current machinery under normal conditions of load.

9. Magnetic circuits consisting wholly or even partly of iron modify these results considerably, especially at frequencies of over 100 periods per second.

It is needless to observe that Professor Pupin held frequent conferences on these matters with the students of the graduating class, and that these conferences were appreciated very much by them. These papers contain the first mathematical analysis of the famous Tesla high-frequency machine and induction coils, the results of which are in perfect accord with experimental data. Certain changes in the arrangements of the Tesla circuits were suggested by the theory which which will be tried experimentally very soon conjointly by Mr. Tesla and Dr. Pupin.

It is also well to observe that these experiments enriched the department with a number of very valuable electrical apparatus, which were bought by contributions from outside sources.

The department has formed a very complete advanced post-graduate course in Practical and Theoretical Electrical Engineering, which will be offered with the beginning of the next scholastic year. The practical part of this course will be in charge of Professor Crocker, and will be offered among the University courses of the Faculty of the School of Mines. The theoretical part will be in charge of Professor Pupin, and will be offered among the University courses under the Faculty of Pure Science. These courses lead to the degree of Ph.D.

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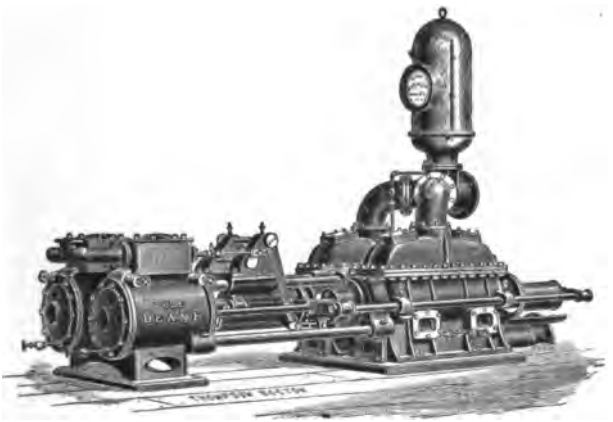

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Columbia College
In the City of New York.

COLUMBIA COLLEGE IN THE CITY OF NEW YORK at the present time consists of the School of Arts, the original college, founded in 1754; of sundry professional schools, to-wit: the School of Law, the School of Mines, and the College of Physicians and Surgeons, admission to all of which, as candidates for professional degrees, is open to all students whether or not they are college-bred men; and of the University Faculties of Law, Medicine, Mines (Applied Science), Political Science, Philosophy and Pure Science, which conduct all courses leading to the university degrees of Master of Arts and Doctor of Philosophy.

The point of contact between the college and the university is the senior year in the School of Arts, during which year students in the School of Arts pursue their studies, with the consent of the Faculty of Arts, under one or more of the University Faculties.

I. THE SCHOOL OF ARTS.

The School of Arts, or the college proper, has a curriculum of four years' duration leading to the degree of Bachelor of Arts. Candidates for admission to the School of Arts must be at least fifteen years of age, and pass an examination on prescribed subjects, the particulars concerning which may be found in the annual Circular of Information.

II. THE UNIVERSITY FACULTIES.

The University Faculties of Law, Medicine, Mines (Applied Science), Political Science, Philosophy, and Pure Science, taken together constitute the University. These university faculties offer advanced courses of study and investigation, respectively, in (*a*) Private or Municipal Law, (*b*) Applied Science, (*c*) History, Economics, and Public Law, (*d*) Philosophy, Philology and Letters, and (*e*) Pure Science. Courses of study under one or more of these university faculties are open to members of the senior class in the School of Arts and to all students who have successfully pursued an equivalent course of undergraduate study to the close of the junior year. These lead through the Bachelor's degree to the university degree of Master of Arts and Doctor of Philosophy.

III. THE PROFESSIONAL SCHOOLS.

The professional schools are the Schools of Law, Mines, and Medicine, to which all students, as well those not having pursued a course of undergraduate study as those who have, are admitted on terms prescribed by the faculty of each school as candidates for professional degrees.

1. The School of Law, established in 1858, offers a course of study covering a period of three years, and designed to give full and accurate instruction in the principles and practice of private and public law. The degree of Bachelor of Laws is conferred on the satisfactory completion of the course, and in addition thereto the degree of Master of Arts is conferred upon college graduates who comply with the conditions prescribed by the University Council.

2. The School of Mines, established in 1864, offers the following courses of study, each of four years' duration, and each leading to an appropriate professional degree, namely, Mining Engineering, Civil Engineering, Electrical Engineering, Metallurgy, Geology and Palæontology, Analytical and Applied Chemistry, Architecture. The degree of Master of Arts is conferred upon college graduates who comply with prescribed conditions. There are, also, an additional course for graduates in Electrical Engineering, and a graduate course in Sanitary Engineering, each leading to an appropriate degree.

3. The College of Physicians and Surgeons offers a three years' course of study in the principles and practice of medicine and surgery, leading to the degree of Doctor of Medicine (M.D.).

SETH LOW, LL.D., President.

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THE

SCHOOL OF MINES QUARTERLY.

VOL. XIV. JULY, 1893. No. 4.

THE RELATION OF THE UNIT STRESS AND CROSS-SECTION IN CURVED MEMBERS.

BY JAS. L. GREENLEAF.

THE expression curved members is intended to represent the elastic arch in its various phases, and also those somewhat rare cases of design in which the members of a structure subjected to tension or compression stress are intentionally curved out of the straight line.

Illustrations of such construction can be had in the rafter of a small roof truss, when, as occasionally occurs, it has been designed in a curve between panel points; in a curved column, such, for example, as an I-beam bent over to act as a small crane, and in other designs now and then met with in practice.

It is in the arch, however, that we find the usual illustration of the term curved member, for the principle of design, "directness of stress, and simplicity," banishes the curve between panel points from all braced structures but small ones, and those in which æsthetic considerations may predominate.

When under stress these curved members are subjected at any one cross-section not only to a direct thrust, or possibly tension, but also to a bending moment, because of the eccentricity of the line of the resultant of the external forces from the neutral axis of the section.

It is desirable, in order to design the member, that the combined

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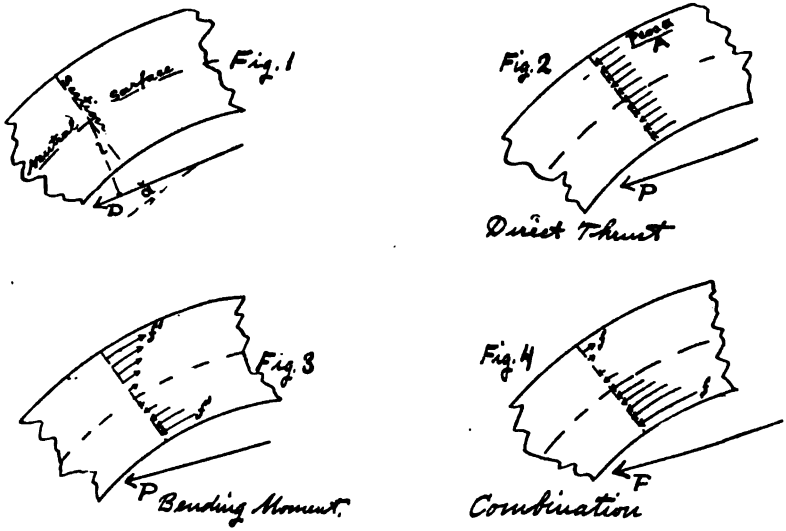
effect of the force direct and its moment at any cross-section be given in one formula; a formula expressing the relation between the unit stress exerted on the fibres, the dimensions of the cross-section of the member, and the resultant of the external forces causing the stress.

Having a general formula of this nature, it is a simple matter to dimension curved members, provided the resultant of the external forces acting upon the member at any section can be located.

The complete determination of this resultant is easy enough in the rare case of a curved strut pinned at the ends, but it offers in-



tricate problems if the strut is fixed at the ends. In the case of the arch the resultant of the external forces is found in the "special equilibrium polygon," which is located by different but well-known methods for the rigid, the two-hinged, and the three-hinged elastic arch.

Turning attention for the present to the general formula for unit stress, Figs. 1 to 4 illustrate the way in which the actual unit stress in a cross-section of the member is combined from those due to direct thrust and bending moment separately.

Let P denote the resultant of the external forces acting on the section; in the case of the arch it is represented by the line of the equilibrium polygon.

A denotes the area of cross section.

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a denotes the angle of P with the tangent to the curved member at the section.

f denotes the *combined* unit stress in the outermost fibre at either extremity of the section indifferently.

f^1 is the similar symbol for stress due to bending moment solely.

The unit stress in the fibres due to direct thrust $= \frac{P \cos a}{A}$.

In case the force P is a compression, as is assumed in the illustration, the combined unit stress f in that part of the section on the *same side* of the neutral axis, as the force P will always be compression, while that in the part of the section on the *further side* of the neutral axis from the force P will be compression or tension, according to the predominating effect of the direct thrust or the bending moment.

The minus sign will be given to compression stress and the plus sign to tension stress.

A study of Figs. 2 to 4 will make the truth of the two following formulas apparent:

$$(A)\ f = -\frac{P \cos a}{A} - f^1.$$

$$(A^1)\ f = -\frac{P \cos a}{A} + f^1.$$

It should be noticed that in this and the following pairs of formulas, the first one of the two gives the unit stress in the outermost fibres of the section on the *same side* of the neutral axis with P, and the second gives the corresponding stress for the fibres on the *further side* of the neutral axis from P.

It will be useful to obtain an expression for f^1 in terms of the dimensions of the section of the member and introduce it in (A) and (A^1), but for this purpose additional notation will be necessary.

Let I denote the moment of inertia of the section about the neutral axis.

r, the radius of gyration corresponding to I.

c, the distance from the neutral axis to the outermost of the section.

R, the moment of resistance of the section.

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M, the bending moment at the section.

According to the familiar law of elasticity of material,

$$\tfrac{1}{2} R = \frac{f^1}{c} \tfrac{1}{2} I, \text{ and as } I = Ar^2,$$

$$\tfrac{1}{2} R = \frac{f^1}{2c} Ar^2, \text{ but}$$

$$\tfrac{1}{2} R = \tfrac{1}{2} M = \tfrac{1}{2} Pl,$$

hence

$$f^1 = \frac{Plc}{Ar^2}.$$

Substituting this value of f^1 in (A) and (A^1),

$$(B)\ f = -\frac{P}{A}\left(\cos a + \frac{cl}{r^2}\right).$$

$$(B^1)\ f = \frac{P}{A}\left(-\cos a + \frac{cl}{r^2}\right).$$

It will be readily recognized that these formulas are in a convenient form for use, for the radius of gyration and cross-section for any particular section can be readily obtained. By means of them one can design the member so that the unit stress in the outermost fibres at either extremity of the section at any point along the length of the member shall not exceed a safe maximum.

Formulas (B) and (B^1) are entirely general, but they can be simplified for certain elementary forms of cross-section, such as the rectangle, circle and others.

For the Rectangle.

$r^2 = \frac{d^2}{12}$ and $c = \frac{d}{2}$, d denoting the depth; hence,

$$(E)\ f = -\frac{P}{A}\left(\cos a + \frac{6l}{d}\right)$$

$$(E^1)\ f = \frac{P}{A}\left(-\cos a + \frac{6l}{d}\right)^*$$

* It is worthy of notice in passing, that formula (E^1) gives a convenient demon-

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For the Circle.

$r^2 = \frac{d^2}{16}$ and $c = \frac{d}{2}$, d denoting the diameter; hence,

$$(E)\ f = -\frac{P}{A}\left(\cos a + \frac{8l}{d}\right).$$

$$(E^1)\ f = \frac{P}{A}\left(-\cos a + \frac{8l}{d}\right).$$

For the plate-girder or lattice-girder for which the assumption is made that the web resists shear only.

Let b and t denote the breadth and thickness of flange respectively, and d denote the distance between the centres of gravity of the two flanges. Then the value of I for one flange about the neutral axis of the girder =

$$\frac{bt^3}{12} + bt\frac{d^2}{4} = \frac{\text{area of flange}}{12}(t^2 + 3d^2),$$

Hence $$r^2 = \frac{t^2 + 3d^2}{12},$$

t^2 is very small compared with $3d^2$, and can be neglected, and hence

$$r^2 = \frac{d^2}{4}.$$

Also $$c = \frac{d}{2}, \text{ hence,}$$

$$(E)\ f = -\frac{P}{A}\left(\cos a + \frac{2l}{d}\right).$$

$$(E^1)\ f = \frac{P}{A}\left(-\cos a + \frac{2l}{d}\right).$$

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stration of the "middle third theory" for masonry, or any material in which a tension-stress is not allowable

Under this condition the extreme eccentricity of the resultant P will be such a value of l that f = zero in equation (E¹).

Placing f = zero, and making cos a = unity—which will be the case when P is normal to the section—and solving, l is found equal to $\frac{1}{6}d$. In other words, P must fall within the middle third of the base.

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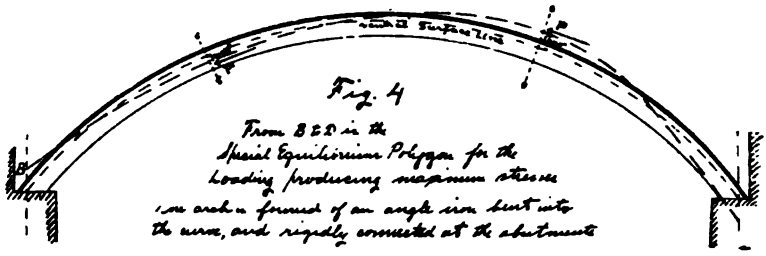
Fig. 4
From B E D in the
Special Equilibrium Polygon for the
Loading producing maximum stresses
in arch in formed of an angle iron bent into
the curve, and rigidly connected at the abutments

A GENERAL APPLICATION OF FORMULAS (B) AND (B¹).

As an illustration for the student, the general formulas (B) and (B¹) will now be applied to an irregular section.

We will suppose an angle iron to be bent into the curve shown in figure 4, and that it is one of a series of similar arch ribs for supporting a small arched roof.

The angle iron is rivetted fast at the springings, and thus the arch rib belongs to the rigid arch type.

It is held from lateral deflection or twisting by the roof framing, and can deflect in a vertical plane only.

The special equilibrium polygon is assumed, for it is foreign to this discussion to explain its construction in detail.

Suffice it to say that the equilibrium polygon shown is assumed to be the proper one for that combination of the loading which will cause maximum stresses in the arch rib.

The sections *ss* and s^1s^1 have been selected as locating the maximum stresses in the rib. It will be noticed that for these sections a = zero.

Study of Section ss.—P is found from the equilibrium polygon to equal 7000 pounds, and l equals 4.0 inches. As a = zero cos a = unity.

f is taken for wrought-iron at 14,000 pounds per square inch. This would be a high working stress for wrought-iron except for the fact that the maximum stress is estimated for a wind pressure, which is unusual, and also that the stiffness of the sheathing and covering is a considerable item in a roof of this span.

The two general formulas are:

$$(B)\ f = -\frac{P}{A}\left(\cos a + \frac{cl}{r^2}\right)$$

for that part of section *ss above* the neutral axis.

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$$(B^1)\ f = \frac{P}{A}\left(-\cos a + \frac{cl}{r^2}\right)$$

for that part of section *ss below* the neutral axis.

Introducing the known terms,

$$(B) - 14{,}000 = -\frac{7000}{A}\left(1 + 4\,\frac{c}{r^2}\right), \text{or } 4\,\frac{c}{r^2} = 2A - 1.$$

$$(B^1)\ 14{,}000 = \frac{7000}{A}\left(-1 + 4\,\frac{c}{r^2}\right), \text{or } 4\,\frac{c}{r^2} = 2A + 1.$$

It remains to select an angle iron whose values of c, r^2, and A will satisfy these conditions most closely.

Shape No. 66, page 105, of the Carnegie, Phipps & Co. handbook gives the dimensions shown in Fig. 5, and is selected for trial.

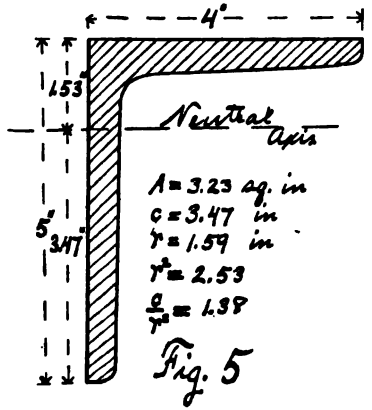

Fig. 5

Introducing the value of A in the two equations,

$$(B)\ 4\,\frac{c}{r^2} = 2 \times 3.23 - 1 \therefore \frac{c}{r^2} = \frac{5.46}{4} = 1.37.$$

$$(B^1)\ 4\,\frac{c}{r^2} = 2 \times 3.23 + 1 \therefore \frac{c}{r^2} = \frac{7.46}{4} = 1.87.$$

The actual value of $\frac{c}{r^2}$ for the angle iron selected is 1.38. This

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shows that the selection is satisfactory so far as concerns the portion of the section above the neutral axis.

For the lower portion of the section, a brief inspection of the formula will show that the unit stress in the outer fibres is less than the maximum allowed if this angle be used, and is therefore safe.

The actual amount can be ascertained thus:

$$(B^1)\ f = \frac{7000}{3.23}(-1 + 1.38 \times 4) = 9800 \text{ pounds tension.}$$

The question still remains whether another angle cannot be used with a higher unit stress in the lower part of the section, and thus economize material.

Trial will answer this in the negative.

For example, a 5 by 5-inch angle, with 0.4 sq. inch greater area, gives unit stresses of $f = -13{,}450$ pounds, and $f = 9500$ pounds for the upper and lower parts of the section respectively. With this angle the unit stresses are not materially altered.

A 4 by 4-inch angle, with an area = 2.86 sq. inches, gives values of approximately — 22,000 and 18,000 pounds respectively, it being entirely too small.

If the angle selected, No. 66, is placed with the 5-inch leg horizontal instead of vertical, the values of f are — 13,600 and 9300 pounds respectively. This immaterial diminution of unit stresses does not offset the desirability of placing the long leg vertical.

If, instead of an angle iron an I-beam had been employed, a considerable saving in material would be effected.

Calculations will show that a 4 inch I-beam with 2.1 sq. inches area of section would be under only — 13,600 and 6440 pounds unit stress respectively, and save 3.76 pounds weight of metal per linear foot of rib. Details of connections might, however, make the angle the more desirable shape to use.

Concerning the section s^1s^1, an investigation is scarcely necessary. The value of P at that section is less than at section ss; l is only 0.5 of an inch, and as the angle iron is the same size throughout its length it will be abundantly strong at section s^1s^1.

Of course, if the snow and wind load were assumed on the left side of the roof the equilibrium polygon would be reversed, and the two sections ss and s^1s^1, with their corresponding discussions, would exchange places.

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THE ADJUSTMENT OF TRIANGULATION.

By E. M. DOUGLAS, C.E.

The following is the application of "The Method of Least Squares" to the adjustment of triangulation as it has been successfully used by the writer in more than a hundred cases.

The particular examples chosen for illustration are from some preliminary work done with an eight-inch Vernier theodolite, and are not given as examples of accurate field-work.

It is assumed at first that there is only one measured base, and that all angles are of equal weight.

The different steps in the adjustment will be given in the following order:

Tabulation of means of observed angles.

Station adjustment.

Reduction to centre.

Figure adjustment.

1. When among a number of observations for finding the value of a particular angle one or more of the observations differ greatly from the mean of all, it is not advisable to leave it entirely to the judgment of the computer to decide which observations shall be retained and which rejected. Pierce's *Criterion*, however, furnishes a fixed rule which will enable the computer to decide whether to retain or reject the doubtful observations.

It is applied as follows:

No.	Observed Angles.	V.	V^2.
1	34°09′17 0″	0.0″	0
2	34°09′22.0″	5.0″	25.0
3	34°09′20.0″	3.0″	9.0
4	34°09′16.5″	0.5″	0.3
5	34°09′17.0″	0.0″	0.0
6	34°09′09.5″	7.5″	56.2
Mean =	34°09′17.0″	Sum =	90.5

Column V. contains the difference between each observation and the mean.

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The sum of the squares of these differences is 90.5. This number must be divided by the number of observations less one,

$$\frac{90.5}{6-1} = \frac{90.5}{5} = 18.1$$

and the quotient (18.1) multiplied by the number from the table of constants for six observations,* which is 2.592:

$$2.592 \times 18.1 = 46.9.$$

Should any number in the column V^2 exceed this product, the observation from which it was found must be rejected.

This rule requires the rejection of observed angle No. 6 and no other. A new mean must now be found for the remaining angles (= 34° 9′ 18.5″).

2. In the following table are given the means of angles taken at Haley Ratlif Station, doubtful observations having been rejected by the rule just given:

Angle Number.	Stations observed.	Mean angles.	Reduction to centre.	Least square corrections.	Corrected angles reduced to centre of station.
1	Taylor Mountain. Corn Hill.....	185°01′28.0″	+26.35″	+5.29″	185°01′59.64″
2	Corn Hill. Hay Stack.....	34°09′18.5″	— 8.64″	+2.03″	34°09′11.89″
3	Corn Hill. Morrison's.....	76°57′45.4″	— 6.90″	+3.26″	76°57′41.76″
4	Haystack. Morrison's.....	42°48′26.1″	+ 1.74″	+2.03″	42°48′29.87″
5	Morrison's. Prairie	43°06′10.1″	—11.43″	+2.55″	43°06′01.22″
6	Morrison's. Taylor Mountain	98°00′35.3″	—19.45″	+2.75″	98°00′18.60″
7	Prairie. Bachelor's Peak..	29°21′32.5″	— 3.86″	+2.55″	29°21′31.19″
8	Batchelor's Peak Taylor Mountain	25°32′47.8″	— 4.16″	+2.55″	25°32′46.19″
9	Centre of signal, Corn Hill. Signal distant 1.52 metres.	62°56′	.....	.....	.....

* For table of constants see Chauvenet's *Astronomy*, vol. ii, page 596; see also page 558, or Lee's *Tables*, page 291.

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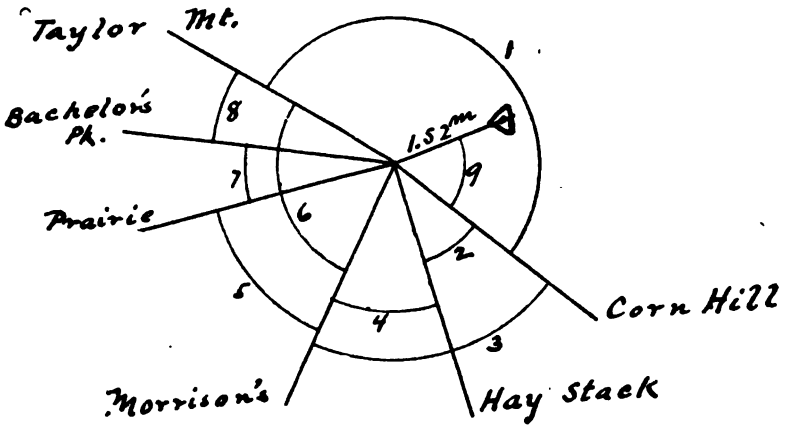
FIG. 1.



3. If the angles were without error, we see by an inspection of the diagram that

No. 5 + No. 7 + No. 8 should equal No. 6.
No. 2 + No. 4 should equal No. 3.
No. 1 + No. 3 + No. 6 should equal 360°.

Since the angles are not without error, corrections must be found which will make the corrected angles fill the conditions above stated.

CONDITIONAL EQUATIONS.

4. Denote the correction for an angle by the angle number enclosed in brackets. Then we shall have

No. 6 + [6] = No. 5 + [5] + No. 7 + [7] + No. 8 + [8].
No. 3 + [3] = No. 2 + [2] + No. 4 + [4].
360° = No. 1 + [1] + No. 3 + [3] + No. 6 + [6].

Or substituting for each angle number the observed value, combining and transposing, gives the following equations:

5. $+[6]-[5]-[7]-[8]+4.90=0$ . . (a).
$+[3]-[2]-[4]+00.8=0$ . . (b).
$-[1]-[3]-[6]+11.3=0$ . . (c).

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6. The usual method for forming these equations would be as follows for equation (a):

No. 5	43°	06′	10.1″
No. 7	29	21	32.5
No. 8	28	32	47.8
Sum. —	98	00	30.4
No. 6 +	98	00	35.3
			+ 4″.90

Give to the largest angle of each set (No. 6 in this case) the + sign, and to the remaining angles the — sign.

The conditional equation (5) can readily be formed from this data alone. Equations b and c may be formed in the same way.

7. These are algebraic equations, and if it were possible from three equations to find the true value of eight unknown quantities, their solution would give the exact correction for each angle.

According to the *Theory of Least Squares*, the *most probable* systems of corrections that can be found from equations of this kind is that in which the sum of the squares of the corrections is a minimum.

The usual method of solving these equations is by the use of correlates or undetermined multipliers, one for each equation of condition.

8. The correlates should be written in tabular form as below, one column being taken for each equation and one line for each angle for which a correction is required.

Angle No.	a.	b.	c.
1	.....	.....	— 1
2	.....	— 1	.....
3	.....	+ 1	— 1
4	.....	— 1	.....
5	— 1	.....	.....
6	+ 1	.....	— 1
7	— 1	.....	.....
8	— 1	.....	.....

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In equation a (5) the unknown quantities are the corrections to be found for angles 5, 6, 7, and 8; the coefficients of these corrections are — 1, + 1, — 1, — 1, respectively.* These coefficients are written in column a of the table on lines numbered 5, 6, 7, and 8.

In a similar manner the numbers in columns b and c are found from equations b and c.†

9. The correlates correspond to sets of observation equations, and may be understood thus: "Eight observations have been taken to find the values of three unknown quantities."

Observation No. 1 gives — 1 c,
" " 2 " — 1 b,
" " 3 " + 1 b — 1 c, etc.

An infinite number of values can be assumed for a, b, and c.

For each of these correlates a normal equation is now to be formed, giving to each one the letter of the conditional equation from which it comes.

10. The complete equations are as follows:

a.	b.	c.	
+ 4.00	0.00	— 1.00	+ 4.90 = 0 (a.)
0 00	+ 3.00	— 1.00	+ 0.80 = 0 (b.)
— 1.00	— 1.00	+ 3.00	+ 11.30 = 0 (c.)

The numbers in each lettered column are coefficients of the letters at the head of the column.

The first equation (a) is formed thus:

11. The first term + 4.00 a, is the sum of the squares of the coefficients in column a, used as a coefficient of a.

The second term 0.00 b is the sum of the products of coeffi-

* These coefficients indicate that in forming a single equation each angle is used once and with a + or — sign, or has a weight 1.

† The number for any angle (360° for example) not requiring a correction can be omitted from the equations and from the correlate table (but it must be used in finding the error). See 55.

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cients in column a, by corresponding ones in column b, giving 0 as the coefficient of b.

The third term is the sum of the products of coefficients in column a (taken as multipliers) by corresponding ones in column c (used as multiplicands), which gives (line 6) $+ 1 \times - 1 = - 1$ as the coefficient of c. The absolute term + 4.90 is the absolute term of conditional equation a. In like manner equation b and c are formed.

The general rule for combining correlates is this:

12. Take the numbers in each lettered column in turn for multipliers, find the algebraic sum of the products of these multipliers by corresponding numbers in each of the lettered columns of the table.* The sum of the products of the numbers in two columns gives one term of the normal equation. The letter of the column from which the multipliers are taken will be the letter for the normal equation to which the sum of the products belongs. The letter of the column from which the multiplicands are taken is the letter of that term in the equation for which the sum of the products is the coefficient.

When multipliers and multiplicands are both from same column, the signs of the products are all +; other products may be plus or minus or equal to zero, according to circumstances.

13. In the normal equations (10), if we commence at any coefficient formed from the sum of squares† and read towards the right and also downwards, we come to coefficients having the same algebraic value. This will be true for all normal equations if properly arranged.

The normal equations may be solved by any of the ordinary algebraic methods.

A form of solution recommended is given below. The details of the solution of normal equations will be given under the head of "Figure Adjustment" (41).

Four columns are now added to the table of correlates (15). In each new column, write the value of the letter of the column, multiplied by the coefficients in the column of the same letter in the first part of the table. Find the sum of all the products on each horizontal line and write it in the column of totals.

---

* By corresponding numbers is meant numbers on the same horizontal line.

† Called diagonal coefficients.

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	a.	b.	c.		Sums.
0 =	+ 4.00	0.00	— 1.00	+ 4.90	+ 7.90 (a.)
	(— ¼)		(+¼)		
		[00]	[— 1.32]	(— 1.23)	
0 =	0.00	+ 3.00	— 1.00	+ 0.80	+ 2.80 (b.)
		— (⅓)	(+ ⅓)		
		[— 1b]	[— 1.76]	[— 0.27]	
0 =	— 1.00	— 1.00	+ 3.00	+ 11.30	+ 12.30 (c.)
	+ 1.00	0.00	— 0.25	+ 1.23	+ 1.98
0 =	0.00	— 1.00	+ 2.75	+ 12.53	+ 14.28
	0.00	+ 1.00	— 0.33	+ 0.27	+ 0.93
0 =	0.00	0.00	+ 2.42	+ 12.80	+ 15.21

$$c = -\frac{+ 12.80}{+ 2.42} = - 5.29.$$

$$b = [- 1.76] + [- 0.27] = - 2.03.$$

$$a = [- 1.32] + [- 1.23] = - 2.55.$$

14. Below is given the completed table of correlatives.

Cor. No.	a.	b.	c.	A. — 2.55.	B. — 2.03.	C. — 5.29.	Totals.
1	.....	.....	— 1	.....	.....	+ 5.29	+ 5.29
2	.....	— 1	.....	.....	+ 2.03	.....	+ 2.03
3	.....	+ 1	— 1	.....	— 2.03	+ 5.29	+ 3.26
4	.....	— 1	.....	.....	+ 2.03	.....	+ 2.03
5	— 1	.....	.....	+ 2.55	.....	.....	+ 2.55
6	+ 1	.....	— 1	— 2.55	.....	+ 5.29	+ 2.74
7	— 1	.....	.....	+ 2.55	.....	.....	+ 2.55
8	— 1	.....	.....	+ 2.55	.....	.....	+ 2.55

The numbers in column of totals are the corrections for the angles whose numbers are given in column at extreme left.

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These corrections added algebraically to angles in (2) will make the corrected values fill the conditions given in (3).

Reduction to Centre.

When it is not practicable to set the instrument over the centre of a station at which observations are to be made, it may be placed over an excentric point and corrections applied to reduce the angles to the values they would have had if the instrument had been set over the station.

15. To find these corrections the following quantities must be known (in addition to the angles already given): First, the angle between the centre of the station and the first distant station to the right of it (angle 9 in the diagram); second, the distance from the centre of the instrument to the station centre (in this case = 1.52 metres); third, the distances from the station at which observations are being made to each of the distant stations (Haley Ratlif to Corn Hill, Haley Ratlif to Haystack, etc.). These distances need only be approximate, and may be found from a computation made with the uncorrected angles. *

If d is the distance of the excentric point (at which angles are taken) from the centre of the station, and a is the angle between the station centre and some distant station, and D is the distance to the distant station, then the correction in seconds for the triangle side D is

$$= \frac{\text{Sine a}}{\text{D}} \times \frac{\text{d}}{\text{sine } 1''}$$

The last term is a constant for each position of the instrument.

The following is the form for reduction to centre of the angles in 2:

Distance from instrument to centre of signal = 1.52 metres.

$$\begin{aligned} &\text{Log. } 1.52 \quad = 0.1818 = \text{d in formula.} \\ &\text{Log. sine } 1'' = \underline{4.6856.} \\ &\text{Log. } \frac{1.52}{\text{Sine } 1''} = 5.4962 = \text{constant.} \end{aligned}$$

In order to make all the logs. additive, the logs. of distances D

* See (48) form for computation of distances. For preliminary computation use 5 place logarithms.

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are subtracted from 10, and reminders written in line A. C. log. distances. Attention must be paid to the signs of the sines.

Reduction to Centre Haley Ratlif.

Stations and log. of distances = D.	Corn Hill. 4.2006	Hay-stack. 4.5409	Morrison's. 4.2764
Angles between signals and stations = A.	62°56′	97°05′	139°54′
Log. sines.....	9.9496	9.9967	9.8090
Log. constant....	5.4962	5.4962	5.4962
A.C.log.dist'nces	5.7994	5.4591	5.7236
Log. of correct'n	1.2452	0.9520	1.0288
Correction.....	+ 17.59″	+ 8.95″	+ 10.69″
Stations and log. of distances = D.	Prairie. 4.3480	Bachelor's Peak. 4.5619	Taylor Mountain. 4.4815
Angles between signals and stations = A.	183°00′	212°21	237°54′
Log. sines.....	8.7188 n.*	9.7284 n.	9.9279 n.
Log. constant....	5.4962	5.4962	5.4962
A.C.log.dist'nces	5.6520	5.4381	5.5185
Log. of correct'n	9.8670 n.	0.6627n.	0.9426 n.
Correction.....	— 0.74″	— 4 60″	— 8 76″

The correction for each line or angle side now being known, the correction for any angle is found by subtracting the correction found for the first side from that found for the second side taken in order of azimuth, *i.e.*, from left to right. Thus for angle 3 subtract + 17″.59 from + 10″.69 = — 6″.90 = correction required.

For angle No. 1 subtract — 8″.76 from + 17″.59 = + 8.76 + 17.59 = 26″.35. A simple rule is this: Change the sign of the

* n. Indicates that the sine of the angle is negative..

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left hand correction and add algebraically the corrections found for the sides bounding an angle. The sum is the correction desired.

The corrections thus found, combined with station corrections (15) and applied to observed angles, give adjusted values which are to be used in figure adjustment.

17. The corrections for station and figure adjustment should really be found from one set of equations, but on account of the enormous increase in the labor of adjustment for a slight gain in accuracy, the adjustments are generally made separately.

Figure Adjustment.

18. The word figure as here used refers to a geometrical figure, made up of triangles, in which, having given the length of one side, any other side may be computed by at least two independent routes.

The object of a figure adjustment is to find from the given set of angles values which will satisfy certain conditions. The conditions are three:

19. *First.*—The angles of each triangle must add up to 180° plus spherical excess.

Second.—The length of a side must be the same, by whatever route it is computed from a given base.

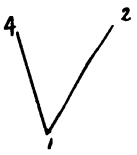
Third.—The adjusted values of the angles must be the most probable that can be found from the observations.

20. The simplest figures are those formed by joining the three points which make a triangle with a fourth point.*

The quadrilateral (23) is a figure of this kind.

21. An angle may be considered to be the difference in azimuth or direction of the two lines bounding it. Azimuths are counted from the south, through the west, north, and east. Therefore the angle 4.1.2 is equal to the azimuth of the line 2.1 minus that of the line 4.1, and may be written: $-4.1.2+$, or $-\frac{4}{1}+\frac{2}{1}$, the number at the vertex of the angle being written underneath the other numbers.

Fig. 2.



22. If written in the ordinary way, 4.1.2, the numbers should be in such order that when the vertex of the angle is towards the observer the left-hand station number is written first. The angle

* The fourth point may be either within or without the triangle formed by the other three.

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4.1.2, if written without signs, would then be read minus the side (or direction) 4.1 plus the side 2.1.

Tri-angles.	Angles.	Corrections to Sides.	Corrections for each Angle.	Corrected Spherical Angles.
	° ′ ″	″ ″	″	° ′ ″
1. 2. 3.	123 26 46.67	+ 1.447 + 0.962	+ 2.41	123 26 49.08
2. 3. 1.	34 09 11.89	+ 0 960 + 1.534	+ 2.49	34 09 14.38
3. 1. 2.	22 23 54.34	+ 1.538 + 1.448	+ 2 99	22 23 57.33
Sum=	179 59 52.90	+ 7.889	+ 7.89	180 00 00.79
	s. e. 0.79			
a.....	Error, — 7.89			
2. 3. 4.	76 57 41.76	+ 0.960 — 0.574	+ 0.38	76 57 42.14
3. 4. 2.	45 15 50 41	— 0.575 — 0.487	— 1.06	45 15 49.35
4. 2. 3.	57 46 28.77	— 0 485 + 0.962	+ 0.48	57 46 29.25
Sum=	180 00 00 94	— 0.199	— 0.20	180 00 00.74
	s. e. 0.74			
b.....	Error, + 0.20			
1. 3. 4.	42 48 29.87	— 1.534 — 0.574	— 2.11	42 48 27.76
3. 4. 1.	105 36 13.12	— 0.575 — 0.088	— 0.66	105 36 12.46
4. 1. 3.	31 35 22.54	— 0.090 — 1.538	— 1.63	31 35 20.91
Sum=	180 00 05 53	— 4.399	— 4.40	180 00 01.13
	s. e. 1.13			
c.....	Error, + 4.40			
1. 2. 4.	65 40 17.90	+ 1 447 + 0.485	+ 1.93	65 40 19.83
2. 4. 1.	60 20 22.71	+ 0.487 — 0.088	+ 0.40	60 20 23.11
4. 1. 2.	53 59 16.88	— 0 090 + 1.448	+ 1.36	53 59 18.24
Sum=	179 59 57.49	+ 3.689	+ 3.69	180 00 01.18
	s. e. 1.18			
	Error, — 3.69			

23. In columns 1 and 2, above, are given the angles of the quadrilateral—Morrison, Haley, Corn Hill, Haystack.* (For convenience, numbers for the stations being used instead of names.)

* All station adjustments and reductions to centre having been made.

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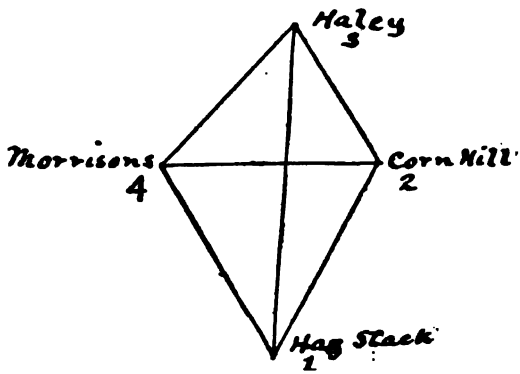
FIG. 3.



In order to find the error of closure of each triangle, the spherical excess must be found. It may be accurately computed by this formula:

24. Spherical excess in seconds,

$$\text{s. e.} = \frac{\text{Area of triangle}}{(\text{square of radius of the earth}) \sin 1''}.$$

The denominator of above fraction is a constant for a given latitude.

Let a and b be any two sides of a triangle, C the included angle and m the constant, then spherical excess = m.a.b. Sine C.

25. The computation of spherical excess is performed as follows: The log. of constant m, for mean latitude of figure, is 1.40540.*

Triangles.	1, 2, 3.	2, 3, 4.	1, 3, 4.	1, 2, 4.
Angles C.....	123°26′50″	76°57′40″	42°48′30″	65°40′20″
Log. side a...	4.36885	4.20055	4.54093	4.36885
" " b...	4.20055	4.27642	4.27642	4.33773
" sine C..	9.92137	9.98866	9.83222	9.95962
" const. m.	1.40540	1.40540	1.40540	1.40540
Log. s. e.....	9.89617	9.87103	0.05497	0.07160
s. e.....	0.79″	0.74″	1.13″	1.18″

* Values of constant log. m. for distances in metres are given in Coast Survey Report for 1884, page 375. When the figures are very large, constants for the mean latitude of each triangle must be used.

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For convenience of reference, write numbers for each triangle corresponding to the angle and sides used; for example, in the triangle 1.2.3, the log. of sides 1.2 and 3.2 and the log. sine of angle 1.2.3 are used.*

For a given latitude, the spherical excess is proportional to the area.†

The triangles 1.2.3 and 1.3.4 cover the same area covered by the triangles 2.3.4 and 1.2.4; hence the sum of the spherical excesses for each pair of triangles should be the same.

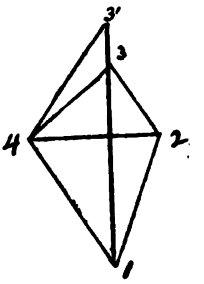
s. e. 1.2.3	= 0.79	0.74 =	s. e. 2.3.4.
s. e. 1.3.4	= 1.13	1.18 =	s. e. 1.2.4
Sum	= 1.92	= 1.92 =	Sum

This check on the correctness of the work should always be applied.

26. In an adjusted quadrilateral there are but three independent triangles, for if all the angles of three triangles are known, those of the fourth triangle may be easily computed from them.

All the angles in a quadrilateral may be so adjusted that each triangle will close without error, and yet if we were to compute from these angles the length of a particular side from a known side by the two independent routes, we would probably find that each route gave a different value for the length of the desired side; on accurately plotting the results, we would possibly get a figure similar to this:

FIG. 4.



27. In a quadrilateral there are, therefore, four independent conditions to be satisfied by an adjustment (not including local conditions covered by station adjustment), three being the closure of triangles, the fourth fixing the relative length of the sides (making 1 — 3 = 1 — 3′ in above figure).

Corrections for the errors in a quadrilateral‡ are found from algebraic equations, one for each independent condition which it is required to satisfy.

* Distances need be only approximate, and are from the preliminary computation.

† It may be approximately found by dividing area in miles by 75.7; quotient is spherical excess in seconds.

‡ Or any other figure.

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28. The corrections to the sides bounding an angle will be indicated by enclosing the side numbers in brackets and prefixing the proper signs. Thus the correction to be found for the angle 4.1.2 is indicated thus: $-[4.1]+[2.1]$ *

In the triangle 1.2.3 (triangle a, 23) for each observed angle write the observed angle and indicate a correction (to be found) as above:

$$1.2.3-[1.2]+[3.2]+2.3.1-[2.3]+[1.3]+3.1.2-[3.1]+[2.1=180+\text{s.e.};$$

or, instead of the angle numbers, write their combined value:

$$179^\circ\ 59'\ 52.9''-[1.2]+[3.2]-[2.3]+[1.3]-[3.1]+[2.1]=180^\circ+\text{s. e.}=180^\circ\ 00'\ 00.79''.$$

29. This equation reduced gives

$$-[1.2]+[3.2]-[2.3]+[1.3]-[3.1]+[2.1]-7.89=0,\ \text{(a)}.$$

In this manner equations are formed for triangles b and c. Triangle 1.2.4 being assumed to be the dependent triangle.

$$-[2.3]+[4.3]-[3.4]+[2.4]-[4.2]+[3.2]+0.20=0,\ \text{(b)}.$$
$$-[1.3]+[4.3]-[3.4]+[1.4]-[4.1]+[3.1]+4.40=0,\ \text{(c)}.$$

To find an equation that will fix the relative length of the sides, proceed as follows:

30. In the figure, 23, having given the side or distance 4.1, compute the sides 3.4 and 3′.4.

$$\text{Side } 3'.4=4.1\times\frac{\text{sin. } 4.1.3'}{\text{sin. } 1.3.'4}.$$

$$\text{Side } 3.4=\text{side } 4.1\times\frac{\text{sin. } 3.4.1}{\text{sin. } 1.3.4}\times\frac{\text{sin. } 3.1.2}{\text{sin. } 1.2.3}\times\frac{\text{sin. } 4.2,3}{\text{sin. } 3.4.2}.$$

The condition that we desire to introduce is that there shall only be one value for side 3.4 = side 3′4 (26).

* Often written thus: $-\left[\frac{4}{1}\right]+\left[\frac{2}{1}\right]$.

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If we make $3'.4 = 3.4$ in above equations, then the points 3 and 3′ will coincide and form one point and the angles 4.1.3′ and 1.3′.4 become 4.1.3 and 1.3.4 respectively. Making these changes and dividing the second equation by the first, we get

$$\frac{\sin. 3.4.1}{\sin. 4.1.3} \times \frac{\sin. 3.1.2}{\sin. 1.2.3} \times \frac{\sin. 4.2.3}{\sin. 3.4.2} = 1;$$

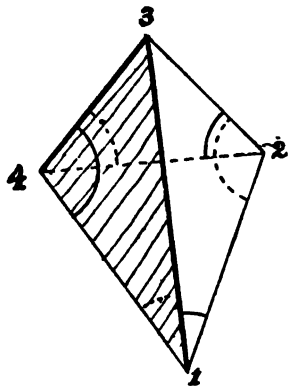
or, using logarithms,

31. Log. sin. 3.4.1 + log. sin. 3.1.2 + log. sin. 4.2.3 — log. sin. 4.1.3 — log. sin, 1.2.3 — log. sin. 3.4.2 = 0.

This is the equation that must be satisfied in an adjusted quadrilateral in order to fix the relative lengths of the sides.

Under the assumption that 2.4.1 is the dependent triangle, its angles being expressed in terms of the others, it can readily be shown that for the computation of any side of the figure (20) from any other side, by the only independent routes possible, the quantities used will give the above equation when the values found for the desired side are made equal. This equation is called the sine or side equation; when it is satisfied the relative lengths of all the sides will be fixed.

FIG. 5.



The question "Which angles are to be used in forming the sine equation?" can be easily answered by the following method:

32. Let the quadrilateral 1.2.3.4 represent the projection of a pyramid, the base of which is the triangle 2.4.1 * and the vertex at 3. The positive sines in the log. sine equation given above are sines of the angles indicated by solid arcs. These are the angles which open towards the front in going around the pyramid in the direction 1.2.4.1.

The angles opening in the opposite direction are those taken with the negative sines. It will be noticed that no angle is used having its vertex at the vertex of the pyramid nor any angle having more than one side in the base of the pyramid.

* The base triangle is usually assumed to be the dependent one.

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The sines of plane or of spherical angles may be used; the latter are usually taken.

33. Arrange the log. sines in the following tabular form, opposite each sine writing its log. difference for one second.* The interpolated values for the 8th place of decimals are retained in order to lessen the error in computation from dropping decimals, the adjustment to seven places of decimals being desired.

Angles.	Log. Sines.	Difference, 1″.	Correc. to Angles.	Correct. to Sines.	Corrected Sines.
			″		
3, 4, 1,	9.9836918.6	— 5.9	— 0.66	+ 3.9	9.9836922.5
3, 1, 2,	9.5809762 8	+ 51.1	+ 2.99	+ 152.8	9.5809915.6
4, 2, 3,	9.9273484.8	+ 13.2	+ 0.48	+ 6 3	9.9273491.1
Sum,.. +	9.4920166.2	.....	.....	+ 163.0	9.4920329.2
4, 1, 3,	9.7191913.9	+ 34 2	— 1.63	— 55.7	9.7191858.2
1, 2, 3,	9.9213757 3	— 13.9	+ 2 41	— 33.5	9 9213723.8
3, 4, 2,	9.8514769.5	+ 20.8	— 1.06	— 22.0	9.8514747.5
Sum,.. —	9.4920440.7 9.4920166.2	.....	.....	— 111.2	9.4920329.5
	Error = — 274.5			274.2	

For a small correction to any of these angles the change in log. sine will be equal to the correction in seconds multiplied by the tabular difference for 1″.

The correction for angle 3.4.1 is denoted by — [3.4] + [1.4], hence the change in the log. sine will be — 5.9 (— [3.4] + [1.4]).

34. Since the difference of the log. sines, 33, does not equal zero, substitute in the equation, 31, for each sine the plus sign, a correction found as above;† after reducing, we get this sine or side equation:

$$+ 5.9\,[3.4] - 5.9\,[1.4] - 51.1\,[3.1] + 51.1\,[2.1] - 13.2\,[4.2] + 13.2\,[3.2] + 34.2\,[4.1] - 34.2\,[3.1] - 13.9\,[1.2] + 13.9\,[3.2] + 20.8\,[3.4] - 20.8\,[2.4] - 274.5 = 0. \quad . \quad . \quad . \quad . \quad (a').$$

In the triangle equations the coefficients of the corrections are

* The log. difference for angles greater than 90° will have a — sign.

† Compare with angle equations, (28).

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all unity. The labor of solution will be lessened if the coefficients in all sine equations are also unity or nearly so.

(a'), being a true algebraic equation, may be divided by any number without altering its value. Dividing it through by 80 * and combining the coefficients of [3.4], [3.2], [3.1], each of which appears twice, gives

35. $+ .334\,[3.4] - .074\,[1.4] - 1.066\,[3.1] + .639\,[2.1] - 1.65\,[4.2] + .339\,[3.2] + .427\,[4.1] - .174\,[1.2] - .260\,[2.4] - 3.427 = 0$, (d).

We now have the equations necessary for the complete adjustment of the quadrilateral, and from them values must be found by means of correlates (see 7), each equation of condition having a correlate, and each correction coefficient giving a correlate coefficient.

The algebraic sum of the coefficients of each correlate will be zero.†

36. Normal equations are formed from the correlates by the rule in (12). For example, equation b: Multipliers are in column b; first multiplicands are corresponding numbers in column a; these give,

Line 5 $+ 1 \times + 1 = + 1$
Line 8 $- 1 \times - 1 = + 1$

Sum $= + 2 =$ coefficient of a, equation b.

The coefficient of b is,

Line 5 $+ 1 \times + 1 = + 1$
Line 6 $- 1 \times - 1 = + 1$
Line 8 $+ 1 \times + 1 = + 1$
Line 9 $- 1 \times - 1 = + 1$
Line 11 $+ 1 \times + 1 = + 1$

Sum $= + 6$

Coefficient of c,

Line 9 $+ 1 \times + 1 = + 1$
Line 12 $- 1 \times - 1 = + 1$

Sum $= + 2$

* Some multiple of 10 is the divisor usually taken.

† Not true when weights are used.

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Coefficient of d,

Line 5	$+1 \times +.339$	$= +.339$
Line 6	$-1 \times -.165$	$= +.165$
Line 11	$+1 \times -.260$	$= -.260$
Line 12	$-1 \times +.334$	$= -.334$
		Sum $= -.090$

The absolute term is taken without change from equation of condition b.

37. *Correlatives.*

Line.	Sides.	a.	b.	c.	d.	A. +1.446	B. −0.486.	C. −0.088.	D. +0.004.	Totals.
1	2.1	+ 1	.....	.....	+ .639	+1.446	.....	.....	+0.002	+ 1.448
2	3.1	− 1	.....	+ 1	−1.066	−1.446	.....	−0.088	−0.004	− 1.538
3	4.1	.....	.....	− 1	+ .427	.....	.....	+0.088	+0.002	+ 0 090
4	1.2	− 1	.....	.....	− .174	−1.446	.....	.....	−0.001	− 1 447
5	3.2	+ 1	+ 1	.....	+ .339	+1 446	−0.486	.....	+0.002	+ 0.962
6	4.2	.....	− 1	.....	− .165	.....	+0.486	.....	−0.001	+ 0.485
7	1 3	+ 1	.....	− 1	.....	+1.446	.....	+0.088	.....	+ 1.534
8	2.3	− 1	− 1	.....	.....	−1.446	+0.486	.....	.....	−0.960
9	4.3	.....	+ 1	+ 1	.....	.....	−0.486	−0.088	.....	−0.574
10	1.4	.....	.....	+ 1	− .074	.....	.....	−0.088	−0.000	− 0.088
11	2.4	.....	+ 1	.....	− .260	.....	−0.486	.....	−0.001	− 0.487
12	3.4	.....	− 1	− 1	+.334	.....	+0.486	+0.088	+0.001	+ 0.575
	Sums	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

38. *Normal Equations formed from above Correlatives.*

	a.	b.	c.	d.		(Residuals.)
a.	+ 6.000	+ 2.000	− 2.000	+ 2.218	− 7.890 = 0	(.001)
b.	+ 2.000	+ 6.000	+ 2.000	− 0.090	+ 0.200	(.000)
c.	− 2.000	+ 2.000	+ 6.000	− 1.901	+ 4.400	(.000)
d.	+ 2.218	− 0.090	− 1.901	+ 2.084	− 3.427	(.000)

The symmetry of the normal equations gives a partial check in their accuracy (see 13). Thus, commencing at the coefficients

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underlined*, and reading downwards or towards the right, the numbers are the same.

40. It will be noticed in the solution of the equation, as given in 14, that certain terms were eliminated, *i.e.*, had no influence on the final values of the correlates. In the solution given below, the corresponding terms will be omitted. They are all those in 38 below and to the left of the diagonal coefficients. The re-remaining terms of the equation a, b, c, d, are written on lines 1, 6, 13, 22.

41. *Solution of Normal Equations.*

	(a.)	(b.)	(c.)	(d.)	Absolute terms.	Line No.
(a.)	+ 6.000	+ 2.000	— 2.000	+ 2.218	— 7.890	1
	0.77815 0.00000 —	0.30103 9.52288 —	0.30103 9.52288 +	0.34596 9.56781 —	0.89708 0.11893	2 3 4
		(+ 0.162)	(— 0.029)	(— 0.002)	(+ 1.315)	5
(b.)		+ 6.000 — 0.667	+ 2.000 + 0.667	— 0.090 — 0.739	+ 0.200 + 2.630	6 7
		+ 5.333 0.72700 0.00000 —	+ 2.667 0.42600 9.69900 —	— 0.829 9.91855 9.19155 +	+ 2 830 0.45179 9.72479	8 9 10 11
			(+ 0.044)	(+ 0.001)	(— 0.531)	12
(c.)			+ 6.000 — 0.667	— 1.901 + 0.739	+ 4.400 — 2.630	13 14
			+ 5.333 — 1.333	— 1.167 + 0.415	+ 1.770 — 1.415	15 16
			+ 4.000 0.60206 0.00000 —	— 0.747 9.87332 9.27126 +	+ 0.355 9.55023 8.94817	17 18 19 20
				(+ 0.001)	(— 0.089)	21
(d.)				+ 2.084 — 0.820	— 3 427 + 2.917	22 23
				+ 1.264 — 0.129	— 0.510 + 0.440	24 25
				+ 1.135 — 0.140	— 0.070 + 0.066	26 27
	a = + 1.446			+ 0.995 9.99782 0.00000 —	— 0.004 7.60206 7.60424	28 29 30 31
	b = — .486					
	c = — .088					
	d = + .004				(+ 0.004)	32

* Diagonal coefficients.

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42. The logarithm of each number in line 1 is placed in line 2* The logarithm (= 0.77815) of the left-hand number is taken on a separate slip of paper, and holding it above, is subtracted from each of the other logarithms. The remainders (the logarithms of quotients) are written in line 3. The number corresponding to the logarithm 0.11893, in the right-hand column, is placed in a parenthesis in line 5 with a sign opposite to that of the number above it in line 1.

43. The logarithms in line 3, columns b, c and d, are to be used as the logarithms of multipliers. The sign of each multiplier is the opposite to that of the number above it, and is written in line 4. The logarithms of multipliers are next placed on a slip of paper, and the logarithms of products found by adding the logarithms of the multipliers to the logarithms of numbers in line 1. For example, using b multiplier (line 3, column 2).

Log. of multiplier = 9.52288 sign —	Numbers.
Log. of product bb = 9.82391 sign —	(— 0.667).
Log. of product bc = 9.82391 sign +	(+ 0.667).
Log. of product bd = 9.86884 sign —	(— 0.739).
(b by absolute term) = 0.41996 sign +	(+ 2.630).

Write the numbers corresponding to these products in line 7 under equation b.† Products belong to the equations having the same letter as the multiplier and in the same columns with the multiplicands.

The algebraic sums of the numbers in lines 6 and 7 are written in line 8. In this manner form the products with the multipliers in c and d columns and add them to c and d equations respectively.

The above process is to be repeated for the numbers in line 8. The products, line 16, are added to the numbers in line 15. Proceed as before with the numbers in line 17. This line has but one multiplier. The logarithm of + 0.995 (line 28) is subtracted from logarithm of .004, the number corresponding to quotient is + 0.004, which is the value of d correlate. The logarithm of this

* To avoid confusion, write all logarithms in red ink.

† Same letter as in multiplier column.

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number (7.60206 sign +) is added to each of the logarithms of multipliers in column d. Thus, commencing at the bottom:

Log. of correlate d $= 7.60206$ sign +

added to log. in line 19, column d, gives the log. of product d multiplier by d $= 6.87332$ sign + No. $= +.001$.

Line 10, d multiplier by d, log. $= 6.79361$ sign + No. $= +.001$

Line 3, d multiplier by d, log. $= 7.16987$ sign —, Number $= -.002$. Each number is written in parenthesis under the log. of its multiplicand.

44. Any line of multipliers corresponds to an equation. Take, for example, line 19, the numbers corresponding to each log. taken with the letter of the column give:

$$-1c + 0.187d - 0.089 = 0.$$

The product of $+0.187$ (log. 9.27126) by the value of d, $(+.040) = +.001$ (nearest unit in third place of decimals),

hence, $$-c + .001 - .089 = 0.$$
$$c = -.088.$$

Take the log. of c and proceed as with log. of d obtaining the numbers $+0.044$ line 12, and -0.029 line 5, for products of c correlate by c column multipliers.

Add algebraically the numbers on line 12, and we get the value of $b = -0.486$. Find its product with b multiplier line 3, and write it on line 5. Add the numbers on line 5 for the value of a.

The values of d, c, b, a, can also be found from lines 28, 17, 8, 1.

For example, $+4.00c - 0.747d + 0.355 = 0$ (line 17), substituting the value of d $(+.004)$ and combining gives,

$$+4.00c + 0.352 = 0,$$
$$c = -0.088, \text{ as before.}$$

If we have a table of reciprocals and Crelle's multiplication tables, or a multiplying machine, they may be used instead of logarithms, for example, line 1:

Find the reciprocal of the left-hand number with its sign

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change, $-\frac{1}{6} = -.167$,* using three places of decimals only: write $-.167$ in line 2 in place of the log. of 6. Using $-.167$ as a multiplier, and all the numbers in line 1 except that in column a as multiplicands, find the products, using Crelle's tables or machine, and write them on line 2 in place of the logs. The product by the right-hand (absolute) number being enclosed in brackets, and placed on line 5. These products are now used as multipliers; they are the numbers corresponding to the logs. in line 3. Products are found as in 44, and are added to the equations on lines 6, 13, and 22. Proceed in the same manner for the lines 8, 17, and 28.

It is often convenient to use the reciprocals in fractional form, and also all or part of the multipliers in the same form.

45. The values found for the correlates must now be substituted in the normal equations (38) to test the accuracy of the solution.

For equation b, commencing at the left:

$$
\begin{aligned}
+ 2.218 \times (+ 1.446 = a) &= + 3.207 \\
- 0.090 \times (- 0.486 = b) &= + 0.045 \\
- 1.901 \times (- \ .088 = c) &= + 0.167 \\
+ 2.084 \times (+ \ .004 = d) &= + 0.008 \\
\text{absolute term,} &= - 3.427 \\
\text{Sum,} &= \quad 0.000
\end{aligned}
$$

This proves the equation correctly solved. In the same way substitute in a, b, and c equations. In equation a, as solved above, there is an error amounting to .001, but as only corrections to the nearest hundredth are desired, this small residual may be neglected.

46. The values of the correlates are next placed at the head of column A, B, C, and D (37), and products by corresponding coefficient in column a, b, c, and d, found and written on the proper lines in A, B, C, and D columns.

The sums of the products on each horizontal line are placed in the column of totals. As a check on this part of the work see that the sum of the numbers in each column = 0.

On each line in the column of totals is the correction for the angle side, the numbers for which are given in the column of sides.

For the angle 1.2.3 = (— 1.2 + 3.2) the correction is as follows:

* The reciprocal will always have a — sign.

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For the side 1.2 (line 4) the correction is, — 1.447.
For the side 3.2 (line 5) the correction is, + .0962.
Hence, for the sides — 1.2 and + 3.2, we have:

$$+ 1.447 = - \text{correction for } 1.2.$$
$$+ 0.962 = + \text{correction for } 3.2.$$
$$+ 2.409 = \text{correction for angle } 1.2.3.$$

The total correction to the nearest hundredth is given for each angle in column 4 (22), and the corrected spherical angles in column 5.

47. The correction for each log. sine is the product of its angle correction by its difference for 1″. For example, sine of angle 3.4.1, Dif. for 1″—5.9, correction for angle = — 0″.66.

$$-5.9 \times -0.66 = + 3.9 = \text{cor. to sine.}$$

The corrections and corrected sines are given in 33.

Computations of distances made with these adjusted angles will not lead to discordant results.

48. The following is a form recommended for distance computations:

Nos.	Stations.	Spherical Angles.	s. e.	Plane Angles.	Logarithms.
	Log. side Corn Hill—Hay Stack =			9 9390069	4.3688482
2, 4, 1,	Morrison	60°20′23.11″	0.39	60°20′22.72″	0 0069931
1, 2, 4,	Corn Hill.....	65°40′19.83″	0.39	65°40′19.44″	9.9596151
4, 1, 2,	Hay Stack....	53°59′18.24″	0.40	53°59′17.84″	9.9078931
		180°00′01.18.	1.18	180°00′00.00″	
		Log. dist. Morrison—Hay Stack =			4.3894563
		" " Corn Hill =			4.3377344

Call the station opposite the known side the new station; it is always to be placed first in the list.

The log. of the known side is written at the head of the column of logs. Angles at each station are placed on the same line with station name.

The log. sine of the plane angle at the new station is placed above the angle, and the arithmetical complement (cosecant) is

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written opposite the angle in the log. column (see 15). Sines of the other angles are written opposite them.

To find the log. distance from the new station to either of the others, omit the sine on line with the name of the old station and add the other three logs. In order to be systematic, the writer always finds the log. distance between the first and last named stations first, the last sine being omitted and the other three logs. added.

Observations of Unequal Weights.

49. In finding the weighted mean of a number of observations of unequal weights, multiply each result by its weight, divide the sum of the products by the sum of the weights, the quotient will be the weighted mean.

Example.

38° — 54′ — 55.0″	× Wt. 1 =	55 (seconds only).
54	× Wt. 1 =	54
56	× Wt. 2 =	112
53	× Wt. 1 =	53
57	× Wt. 2 =	114
Sum	7	)388
		55.4

Weighted mean = 38° 54′ 55″.4.

50. Weights are used in a least square adjustment in the following manner: the adjustment is carried forward as above described till the table of correlates is reached; then opposite each angle number in a station adjustment or opposite the side numbers in a figure adjustment, place the weight of the angle or side in a separate column. Every product formed in the table of correlates must be divided by the weight written on the horizontal line with the multiplicand. *The weight is used only as a divisor.*

The following example from a station adjustment will illustrate the method of using weights in station or figure adjustment.

Equation a (51) is formed thus:

— 1 × — 1 ÷ 2 =	+ 0.50 (line 1).
+ 1 × + 1 ÷ 1 =	+ 1.00 (line 2).
— 1 × — 1 ÷ 2 =	+ 0.50 (line 3).
Sum =	+ 2.00 = term a, equation a.

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Term b, same equation = .

$$+ 1 \times - 1 \div 1 = - 1 \quad \text{(line 2)}.$$

Term c = 0. The absolute term — 3.00 is the same that it would have been for an unweighted equation.

Equation c is formed thus:

term a = 0.
term b = $+ 1 \times - 1 \div 2 = - 0.50$ (line 5).
term c = $- 1 \times - 1 \div 1 = + 1.0$ (line 4).
$+ 1 \times + 1 \div 2 = + 0.50$ (line 5).
$- 1 \times - 1 \div \frac{1}{8} = + 3.00$ (line 6).

Sum + 4.50 = term c.

No. of Correct.	Weight.	a.	b.	c.	A. + 2.779	B. + 2.558	C. — 0.605	Totals.	Totals. / Weights.
									"
1	2	— 1	.....	.....	— 2.779	.....	.....	— 2.779	— 1.39
2	1	+ 1	— 1	.....	+ 2.779	— 2.558	.....	+ 0.221	+ 0.22
3	2	— 1	.....	.....	— 2.779	.....	.....	— 2.779	— 1.39
4	1	.....	.....	— 1	.....	.....	+ 0.605	+ 0.605	+ 0.60
5	2	.....	— 1	+ 1	.....	— 2.558	— 0.605	— 3.163	— 1.58
6	⅓	.....	.....	— 1	.....	.....	+ 0.605	+ 0.605	+ 1.81
7	4	.....	— 1	.....	.....	— 2.558	.....	— 2.558	— 0.64
360°	∞	.....	+ 1	.....	.....	.....	.....	.....	0

51. *Equations Formed from Above Correlates.*

a.	+ 2.000	— 1.000	.....	— 3.00 = 0.
b.	— 1.000	+ 1.750	— 0 500	— 2.00 = 0.
c.	.....	— 0.500	+ 4.500	+ 4 00 = 0.

The equations are solved in the ordinary way. The values for the correlates are multiplied by their respective coefficients, the products being written in columns A, B, C, no attention being paid to the weights until after the totals for each horizontal line are found and written in the column for totals. *These totals must be divided by the weights.* The quotients, written in the right-hand columns are the weighted corrections for the angles, the numbers of which are in the left-hand column.

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Adjustment of Figures Requiring More Than Four Equations.

52. If L represents the number of lines in a triangulation scheme, sighted over in both directions, and S the number of stations, the number of equations necessary for the complete adjustment of the figure is as follows:*

$$\text{Number of angle equations} = L - S + 1.$$
$$\text{Number of sine equations} = L - 2S + 3.$$

It makes but little difference which triangles are used in the equations so long as they are independent.

Independent triangles between given points will not cover the whole area twice, but they may overlap (as in a quadrilateral).

53. In order to determine which triangles and angles to use in the equations, roughly plot the figure commencing with any line. As each station or line is added calculate from the above formulas the equations necessary in adjustment; every new equation will be

Fig. 6.

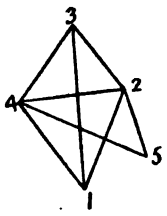


Fig. 7.

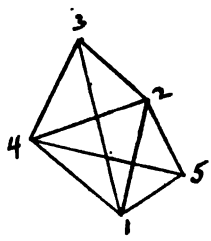
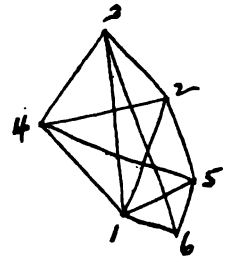


Fig. 8.



for lines to the new point. For example take the figure 1.2.3.4, the adjustment of which has been given, and add a new station 5 and the lines 5.2, 5.4. The formula calls for four angle equations and 1 sine equation; all but one angle equation of these as we have seen, belong to the figure 1.2.3.4; evidently, then, the new angle equation comes from the triangle 5.2.4.

Add the line 5.1. We must now have 2 sine equations and 5 angle equations. The line 5.1 added two triangles to the figure, viz., 5.2.1 and 5 4.1. Either of these may be used for the angle equation; it also completed a quadrilateral 5.2.4.1. Assuming

* Station adjustments not included.

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this quadrilateral to be the projection of a pyramid, we can find the angles to use in a sine equation by the method used in 32.

If we add another station 6 to this figure and the lines 6.1, 6.5, 6.3, the formula requires 7 angle equations and 3 sine equations.

The new angle equations will be 6.3.1 and 6.5.1. To find the sine equation leave out of the figure any point not necessary to make a closed polygon with the lines from 6,–4 may be left out, hence the sine equation must come from the pentagon 1.6.5.2.3.

Assume a pyramid the vertex of which is at 1, the base being 6.5.2.3. The angles for the sine equation may be found in the same manner as for a simpler pyramid (32).

54. In complex figures requiring only a single sine equation the vertex of the pyramid should be taken at that station from which most lines radiate. Have as few terms as possible in the sine equation, *i.e.*, in selecting sine equations from complex figures, choose the simplest figures allowable. Every line in a given figure must appear at least once in a sine equation.

55. The adjustment of an extended scheme of triangulation in a single figure usually involves more labor than is practicable; it is therefore customary to divide the work into small blocks, the size of which depends on the character of the work.

Except for work of the highest class it does not seem advisable to adjust a figure involving the solution of more than 8 or 10 equations in one group.* Disagreement between groups at junction lines may be avoided in two ways. The correction found for a line or angle from one figure may be taken as final, the corrected value being introduced into subsequent figures with an infinite weight. The corresponding correlate coefficients in the latter figures being divided by the infinite weight are reduced to zero, and may therefore be entirely omitted from the equations of condition and the table of correlates. †

If this method is adopted the best figures should be adjusted first, *i.e.*, figures having a large relative weight, or which are made up of well-shaped triangles.

In the figure 1.5.2.3.4, 53, which is from triangulation in Texas,

* Seventy-seven equations were adjusted in England in a single group (Clarke's *Geodesy*).

† When there are quantities thus to be omitted, their algebraic sum may be retained in the table of correlates for a check on the sums of numbers in each column (see 46), but they must not be used in forming the equations.

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corrections for the directions 1.5 and 5.1 were found from a previous adjustment. Following the method above outlined the directions 1.5 and 5.1 were given an infinite weight in the table of correlates. Then, in forming the normal equations, products from numbers on lines 1.5 and 5.1 in the table of correlates, when divided by infinity, became zero, and hence had no effect on the normal equations or the column of totals divided by the weight.

The second method of getting rid of disagreements is to adjust each block independently, and then to make a new adjustment of an intermediate small block, giving the extreme sides an infinite weight.

Where figures have only a single line in common, often it will not be necessary to pay attention to slight disagreements from separate adjustments.

56. In a long computation by a single computer mistakes are very likely to occur. It is a great advantage to know how to find errors quickly.

In order to lessen the chances of error, all computations should be made as nearly mechanical as possible.

Computation books should be ruled with faint blue lines into squares of about $\frac{1}{8}$ of an inch each; a whole square is taken for each figure. Whenever possible, keep the work in tabular form, with dividing lines ruled.

Long computations should be worked in duplicate. Do not crowd the work; paper is cheap.

The greatest part of the labor of an adjustment is usually in the solution of the normal equations. Therefore, great care should be taken in previous steps of the work. The equations may be incorrectly formed, and yet values found from them will close and check in the correlate table. One of the most common mistakes is in combining angles; where two angles and their sum are used in separate triangles they are often incorrectly adjusted, and the error is not noticed till the figure adjustment is nearly completed. After the angles are copied into the tabular form (23), they should be carefully checked. Care must be taken in finding sines and in giving the — sign to the tabular difference for angles over 90°.

If, on substituting the values found for the correlates in the normal equation, they do not close, *i.e.*, reduce to zero, find the residual for each equation. The equation having the largest

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residual is the one where the error is. Look first for errors in signs in that equation, then for misplacement of the decimal point, and next for errors in adding or substracting, then for errors in the products, which may be due to incorrect multipliers.

It will usually be necessary to keep one or two more decimal places in the equations than are desired in the final work. Errors arising from dropping decimals may reach large proportions. It is often possible, as the work progresses, to make arbitrary allowances for the figures dropped. If the diagonal coefficient is less than unity, keep at least two extra decimal places in that equation. The remainders from diagonal coefficients are always +.

57. Residuals from normal equations, if small, can be distributed by finding from them corrections to the values of the correlates. Find the residual for each equation with its proper sign, assuming the correlate coefficients and multipliers to be correct, use the residuals in place of the absolute quantities in the equation, and find from them new values for the correlates; these combined algebraically with the values previously found will give values that will close the equation. As all the products are in the residual column, the new values can be quickly found. This is a method of doubtful value, and should not be resorted to in careful work.

58. When the full equations are used, as in 14, a partial check on the solution can be carried forward as follows:

Keep a separate column for the algebraic sums of numbers in each equation. Find products of these sums by each multiplier in turn, and write products on line with other products from same multiplier. The sum of the products should equal the product in the sum column. This does not give a check on the multiplier itself nor on the numbers used in substituting to find values for the correlates.

For further information on the subject of Least Squares as applied to the adjustment of triangulation, the following works may be consulted:

Wright, T. W.—Treatise on the Adjustment of Observations, New York, 1884.

Johnson, J. B.—The Theory and Practice of Surveying, New York, 1891, page 511.

U. S. Coast Survey Reports for 1854–1855, 1878 (appendix 8), 1882 (appendix 9).

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Wheeler, Lieut. G. M.—Annual Report U. S. Geographical Survey, Washington, 1878, page 28.

Clark, Col. A. R.—Geodesy, Oxford, 1880.

Chauvenet, William.—Manual of Spherical and Practical Astronomy, Philadelphia, 1891, vol. ii.

U. S. Army Professional Papers, No. 24, Washington, 1882.

Merriman, Mansfield.—A Text-Book of Least Squares, New York, 1884.

Gore, J. Howard.—Elements of Geodesy, New York, 1886.

Both Wright and Johnson give, besides the exact solution, approximate methods of adjustment.

THE DETERMINATION OF CARBONIC ACID IN WHITE LEAD.

By FREDERIC C. A. MEISEL,

In the examination of white lead, one of the most frequent determinations to be made is that of carbonic acid. When a number of determinations of any kind are to be made in a limited space of time, it is very desirable to have some quick and at the same time accurate method.

As the determination of carbonic acid in white lead is made for the purpose of knowing the percentage of lead carbonate present, all errors of analysis are multiplied more than six-fold* on calculation, and as the percentage of lead hydrate present is found by difference; its correctness also depends wholly on the accuracy of the carbonic acid determination.

In the past few months I have experimented upon the following methods:

1. Method by loss on ignition, calculating by formula from total per cent. of loss on ignition (CO_2 and H_2O present) the per cent. of CO_2 and H_2O in the white lead.

* $PbCO_3$ contains only 16.48 per cent. CO_2. The percentage of CO_2 obtained on analysis must, therefore, be multiplied by 6.068 to get the percentage of $PbCO_3$ it is equivalent to. If an error of one milligramme is made, say in weighing the potash bulb in method No. 4, it causes an error of only 0.1 per cent. in the per cent. of CO_2, but gives 0.6068 per cent. error in the per cent. of $PbCO_3$.

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2. Method by loss using alkalimeter.

3. Volumetric methods (measuring gas obtained by ignition of known amount of white lead).

a. Without oxidizing agents.

b. With oxidizing agents.

4. Method commonly employed for all carbonates by absorption in KOH and weighing. (Given in table as the absolute method.)

The first three methods take comparatively little time.

The method by loss on ignition is very rapid, but the results obtained are always high, owing to impurities, such as acetate of lead, organic matter, etc.

The following formula may be employed for calculating the respective percentages of carbonic acid and water present:

Let

A = per cent. total loss.

x = per cent. CO_2 y = per cent. H_2O.

then,

$$x = \frac{13.388\,A - 100}{7.320} \text{ and } y = A - x.$$

This formula is obtained as follows:

$Pb(OH)_2$ contains 7.46 per cent. H_2O.

$PbCO_3$ contains 16.48 per cent. CO_2.

Any combination of $PbCO_3$ and $Pb(OH)_2$ on ignition loses all the H_2O and CO_2 present, leaving PbO.

Now, let

A = per cent. total loss.

x = per cent. CO_2 in the mixture of carbonate and hydrate.

y = per cent. H_2O in the mixture of carbonate and hydrate.

then,

$$A = x + y,$$

and using percentages given above,

$$x \times \frac{100}{16.48} + y \times \frac{100}{7.46} = 100,$$

$$x \times 6.068 + y \times 13.388 = 100.$$

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substituting for $y\ A - x$, we get,

$$6.068\ x + 13.388\ A - 13.888\ x = 100,$$
$$13.388\ A - 100 = 7.320\ x,$$
$$x = \frac{13.388\ A - 100}{7.320}$$

and

$$y = A - x,$$

as given. This formula is good, therefore, no matter in what proportion the hydrate and carbonate of lead are present.

With the alkalimeter good results were obtained on pure carbonate of lime, but with the white leads used it seemed impossible to obtain concordant results, except in one or two instances.

The volumetric methods were tried in an apparatus devised by G. W. Thompson. It consists of a water-jacketed, graduated glass tube filled with mercury. The mercury enters this tube from the bottom by a heavy rubber tubing which is connected with a reservoir of mercury, which can be raised or lowered at will. This apparatus is held on a suitable stand made of wood. The upper end of the graduated tube is open, and is connected by means of a short piece of stout rubber tubing to the small long-necked glass bulb in which the white lead is ignited.

By introducing a weighed amount of white lead into the glass bulb, bringing the mercury in the graduated tube and reservoir to an equal level, and taking the reading, the number of cubic centimetres of gas driven off on ignition can be found by again bringing the mercury in tube and reservoir to an equal level. By making allowance for the tension of the aqueous vapors present, and reducing to 0° and 760 mm. the percentage of carbonic acid can readily be calculated. In using this apparatus it is necessary to lower the reservoir containing the mercury, as the gas coming off depresses the mercury in the glass tube, to prevent the blowing out of the glass bulb during ignition.

The presence of acetates and organic matter renders this method without any modifications useless. I thought, however, that by washing out the acetate of lead the errors caused by organic matter might be remedied by the introduction of a weighed amount of some oxidizing agent. By this means any carbonaceous substance would be burnt to CO_2 which would be equal in volume to the oxygen thus consumed. By calculating, therefore, the amount of

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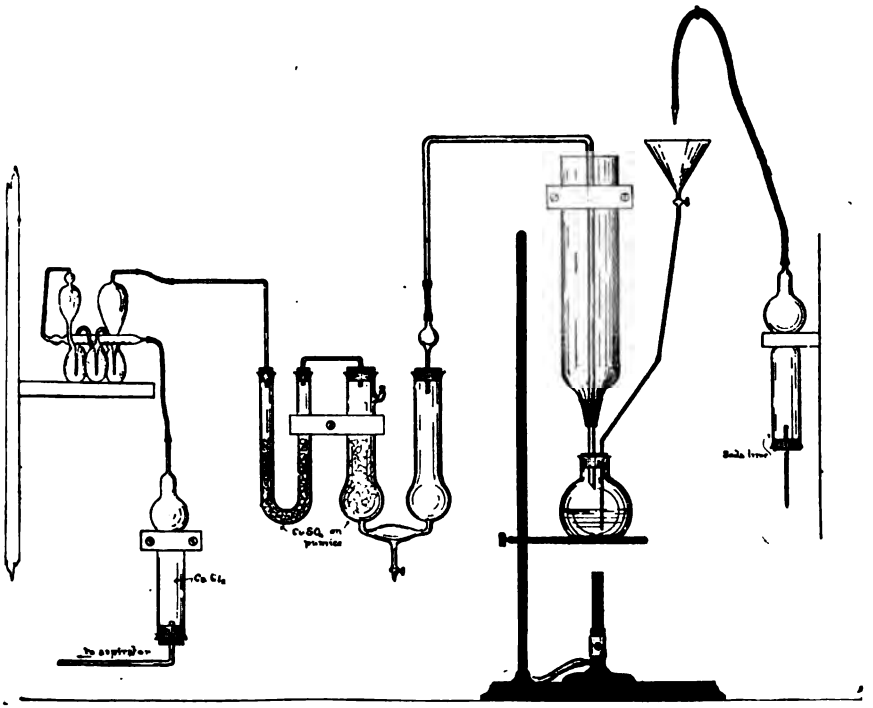
oxygen thus introduced, and subtracting from the total volume of gas given off, the correct volume of CO_2 could be obtained. Potassium chlorate, red lead, and other reagents were tried, but, while in some cases the results obtained were quite satisfactory, with the majority of white leads tried they were not so.

I have, therefore, decided to use only the method last named in the list, which, though slower, is decidedly the most accurate. The drawing below represents the apparatus as used.

One determination takes about fifty minutes. Very little atten-



tion is necessary after once starting. The suction is produced by a stream of H_2O falling from a large demijohn, as shown; 60–70 cubic centimetres of hydrochloric acid (1 : 2) about 10–11 per cent. are used with one gramme of white lead. After bringing to boiling, which should take about ten minutes, five minutes further boiling usually takes all the lead in solution. As soon as this is accomplished the flame is lowered and suction is begun. After fifteen minutes the flame is withdrawn entirely, the suction being continued for twenty minutes more, when the operation is complete.

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The potash bulb is allowed to remain in the desiccating case half an hour or more before weighing. At the end of that time, if any difference of level of solution in the various parts of the bulb is observed, the caps at the ends should be removed to equalize the pressure. The bulb may then be weighed.

The following table compares a few of the results obtained by the above described methods on various samples of white lead:

Method.

Brand.	Absolute? (Method No. 4.)	Ignition.	Volumetric.	Volumetric, with Oxid. agt.	Alkalimeter.
...	.....	.....	12 74	.....	.....
...	12.01	.....	12.75	.....	.....
1	12.26	.....	12.80	12.21	.....
...	.....	.....	.....	13.02	.....
...	12 39	.....	.....	12.89	.....
2	12.31	.....	12.77	13.01	.....
3	.....	.....	12.52	12.64	.....
...	.....	.....	12.42	.....	.....
4	11.79	.....	12.54	11.91	.....
5	11.74	.....	12.84	12.40	.....
6	.....	.....	12.69	12.39	.....
7	11.24	11.32	11.27	.....	.....
8	11.86	12.27	.....	.....	.....
9	12.30	12.56	.....	.....	.....
10	12.60	12.68	.....	.....	.....
11	11.90	12.75	12.15	.....	.....
12	11.27	.....	.....	.....	11.14
13	13.11	.....	.....	.....	12.85

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MINERALOGICAL NOTES.

By ALFRED J. MOSES, Ph.D.

The Gangue of Arizona Ettringite.

In the June, 1893, number of the *American Journal of Science* I described the occurrence, in an ore-shoot of the Lucky Cuss mine, Tombstone, Arizona, of a white fibrous sulphate of lime and alumina containing after deduction of about 4 per cent. of silicate and recalculation to 100:

CaO,	26.31
Al_2O_3,	9.72
SO_3,	18.54
H_2O (115°),	34.53
H_2O (red heat),	10.88

This mineral corresponded very closely to the rare sulphate, ettringite, hitherto known to occur only at Ettringen in the Laach District, and both my analysis and that of Prof. Lehmann corresponded to a simple type formula,

$$2\ R_2O_3,\ SO_3 + nH_2O,$$

in which the two analyses yielded:

$$\text{Arizona.—}H_{28}Ca_{10}Al_4O_{30}5SO_3 + 40H_2O,$$
$$\text{or } 2[H_{\frac{14}{5}}\ CaAl_{\frac{2}{5}}O_3]\ SO_3 + 8H_2O.$$

$$\text{Ettringen.—}H_{18}Ca_6\ Al_2O_{18}3SO_3 + 24H_2O,$$
$$\text{or } 2[H_3CaAl_{\frac{1}{3}}O_3]SO_3 + 8H_2O.$$

The ettringite occurred incrusting a massive silicate from which it had apparently been produced by the action of sulphuric acid, as the silicate underlying the sulphate was usually loosely coherent and corroded, and chiefly composed of the same bases.

The silicate is more or less contaminated with the ore-material, especially oxide of iron (limonite) which in patches colored the mineral brown and yielded as high as 16 per cent. of Fe_2O_3, it con-

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tained also varying amounts of copper and lead as sulphides and carbonates. No complete analysis was made, the undetermined portion being in part CO_2, in part other metallic bases. The analyses nevertheless show a considerable degree of constancy when the ore constituents are omitted and the balance recalculated to 100:

	I. White carefully selected material.	II. Pale green, less pure material.
SiO_2,	36.52	32.27
Al_2O_3,	17.17	14.99
Fe_2O_3,	.80	3.55
CaO,	10.19	8.48
MgO,	1.94	.95
Na_2O,	.93	.....
PbO,	3 35	2.64
CuO,	5.92	4.19
H_2O at 110°,	3 54	5.01
H_2O, red heat,	9.49	9.81
S,	.32	not determined.
CO_2,	not determined.	not determined.

Assuming the iron to be limonite and deducting water corresponding, deducting also PbO, CuO and S and recalculating to 100 we obtain:

	I.	II.
SiO_2,	45.86	45.50
Al_2O_3,	21.56	21.14
CaO,	12.79	11.96
MgO,	2.43	1.34
Na_2O,	1.16	.....
H_2O at 110°,	4.45	7.07
H_2O at red heat,	11.74	12.98

The close agreement is evidently not a mere coincidence. As No. 1 was made upon the purer material it may fairly be assumed to most closely approach the true composition of the silicate. The approximate ratios are for this:

	I.			Approximate ratio.
SiO_2,	45.86 ÷ 60.4	.759		15
Al_2O_3,	21.56 ÷ 10.2	.211		4
CaO,	12.79 ÷ 56	.228	.958	19 or 18
MgO,	2 43 ÷ 40.3	.060		
Na_2O,	1.16 ÷ 62.1	.018		
H_2O red heat,	11.74 ÷ 18	.652		
H_2O at 110°,	4.45 ÷ 18	.247		5 or 6.

That is we have closely an orthosilicate

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$$Al_8R_{18}(SiO_4)_{15} + 6H_2O \text{ or}$$
$$Al_8H_{24}(CaMgNa)_6(SiO_4)_{15} + 6H_2O.$$

The mineral when purest is nearly white or pale green, but is often brown from iron. Specific gravity 2.66 (light colored). When heated the powder becomes a dull olive green. Before the blowpipe swells and fuses easily with intumescence to a dark glass. With soda yields a globule of copper.

The composition and specific gravity suggest a mineral similar to wernerite, in which OH has replaced part of the lime and soda.

Gypsum Crystals from Utah.

Talmadge describes in *Science* * a remarkable occurrence of gypsum crystals in a cave at South Wash, Wayne County, Utah.

Fig. 1.

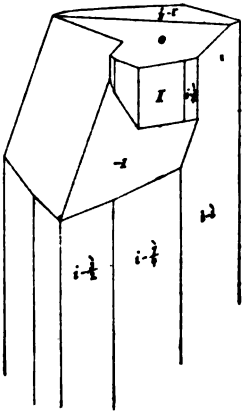
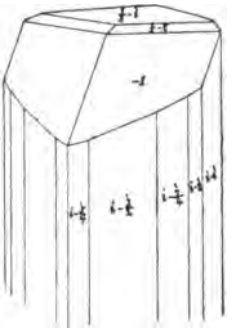


Fig. 2.



Two of these crystals were sent to the School of Mines by Mr. Talmadge, and later at least half a ton of magnificent crystals arrived. All of these were carefully examined, measurement being necessarily limited to the hand goniometer, and the two here figured were the most notable crystallographically.

Fig. 1 shows the occurring faces on a very perfect crystal 27 inches long and approximately 6 broad and 4 thick. The prism faces were those of the two clino prisms $i-\frac{7}{4}$ and $i-\frac{8}{5}$ except upon a curious prismatic extension which pierces the upper right pyramid plane and extends upward about one inch to the basal

* February 17, 1893, pp. 85–86.

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plane common to this and the rest of the crystal. The other occurring planes are the minus hemi-pyramid – I the ortho dome $\frac{1}{3}-\bar{1}$ and the base ,o. Six phantom terminations parallel to the base and ortho dome $\frac{1}{3}-\bar{1}$ are visible.

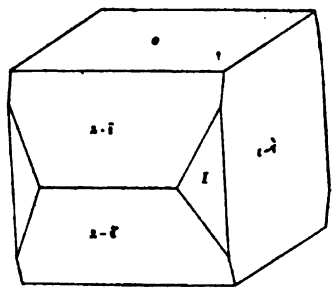
Fig. 2 was the most perfectly terminated crystal received, and was especially noteworthy from the presence of two hitherto undescribed forms, the clino dome $\frac{1}{3}-\grave{1}$ and the prism $\grave{1}-\frac{\grave{5}}{4}$. The faces observed upon this were:

Pinacoid, $\grave{1}-\grave{1}$.
Prisms, $\grave{1}-\grave{1}$, $\grave{1}-\frac{\grave{7}}{4}$, $\grave{1}-\frac{\grave{3}}{2}$, $\grave{1}-\frac{\grave{5}}{4}$.
Domes, $\frac{1}{3}-\bar{1}$, $\frac{1}{3}-\grave{1}$.
Pyramids, — 1.

Heulandite and Stilbite from Upper Montclair, N. J.

Specimens of bright red and brownish heulandite from Mc-

Fig. 3.



Dowell's quarry, Upper Montclair, N. J., consisted of crystals of the form here figured, agreeing essentially with those from Jones Falls near Baltimore. It is noteworthy that while the brownish crystals are comparatively fresh and with bright faces the red crystals are very much corroded and their cleavages under even moderate magnification show the red color to be due to minute translucent blood-red grains irregularly distributed upon the cleavage planes. Kenngott has stated that the red color of the Fassa heulandite is due to minute crystalline grains of another mineral.

The stilbite occurring with the heulandite is frequently of a brilliant brick-red to brownish-red color; this, however, appears to be only external, and to be a powder lacking the translucency of the coloring matter of the heulandite.

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MINERALOGICAL NOTES.

By LEA McI. LUQUER.

Optical Examination of Muscovite from the King's Bridge Ship Canal.

The muscovite crystals examined were found in recently quarried dolomitic limestone, within 300 feet of the eastern end of the "Harlem River Improvement" cut at King's Bridge, N. Y.

The associated minerals were crystallized pyrite, dolomite and quartz.

The crystals were of a pale green color, rather small in size, and of the ordinary hexagonal type with plane angles of 120°. Sometimes the crystals were grouped in rosettes, sometimes in stellate forms, but more generally in step-like aggregations, laminæ from which gave complicated interference figures. The muscovite was not decomposed by sulphuric acid, did not yield water in a closed tube and before the blowpipe lost color and fused to a white glass. The axial angle was found to be quite large, the plane of the optic axes at right angles to the plane of symmetry, thus being a mica of the first order, and the interference colors very bright.

The dispersion was also found to be $\rho > \upsilon$.

The following apparent axial angles were obtained:

$2E\rho =$	$2E\upsilon =$
61° 27′	61° 00′
63° 45′	62° 13′
61° 20′	58° 40′
62° 11′	60° 37′

Crystallized Talc.—Its Supposed Occurrence at Amity and Sing Sing, N. Y.

A so-called specimen of crystallized talc, from Amity, N. Y., has been proved to be white clinochlore. It has the hexagonal type of crystals of that species, easy basal cleavage and pearly lustre on cleavage faces. It appears to be very nearly uniaxial, with strong double refraction and + optical character. It fuses to a white glass, is practically insoluble in hydrochloric acid, yields water and gives test for silica. The associated minerals are serpentine and fluorite.

A so-called specimen of crystallized talc, from the prison quarry, Sing Sing, N. Y., has been proved to be muscovite. It occurs in

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very small thin crystals of a pale green color, with pearly lustre on cleavage faces. The crystals are hexagonal in type with plane angles of 120°. The plane of the opic axes is at right angles to the plane of symmetry, hence the mica is of the first order, and the apparent axial angle is quite large, being for red light 50° 30′. It fuses quite easily to a white glass, and is found associated with large gray crystals of dolomite.

Chemical analyses were not made on either of these minerals, both on account of lack of material and because the optical and blowpipe tests seemed to settle their identity beyond a reasonable doubt.

Microcline from Pitcairn, N. Y.

The feldspar from this locality occurs in dull, bluish-white crystals having very much the appearance of unglazed porcelain. It is commonly associated with bright green pyroxene crystals with polished faces. A section of a crystal of this feldspar, parallel to

the basal pinacoid, showed between crossed nicols the right-angled polysynthetic twinning characteristic of microcline, also a rather symmetrically arranged intergrowth with albite; see figure.

A section parallel to the brachy pinacoid showed a banded intergrowth with albite. The bands being arranged in the general direction of the vertical axis, and showing the + extinction angle of about 19° of albite.

Green Sandstone from Nashville, S. D.

This green granular rock was rather interesting from the fact that at first sight it appeared very much like chrysolite or a fine

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grained coccolite. A section showed it to be composed of small rounded grains of quartz, quite uniform in size, the cementing material being ferruginous and green in color. Grains of calcite were also noticed and a few grains of a black ferruginous garnet-like mineral.

YTTRIALITE FROM LLANO CO., TEXAS.

A thin section of yttrialite from this locality was made at right-angles to the easy fracture. It appeared pale yellowish-green by transmitted light, and between crossed nicols was completely isotropic and homogeneous. Faint parallel lines or markings were noticed resembling cleavage or accretion lines. These made an angle of about 120° with the approximately parallel lines of easy fracture. A large number of minute granular inclusions were also noticed, these seeming to be most plentiful along the above-mentioned lines or markings. Normal to some of these lines were observed what appeared to be quite thick microlitic growths.

The permeating lines mentioned by Hidden and Mackintosh were also noticed.

For a full description of the chemical and remaining physical properties, see article by Hidden and Mackintosh in *Am. Journal of Science*, Vol. XXXVIII., December, 1889.

ORTHOCLASE CRYSTAL, ENCLOSING PYROXENE, FROM RENFREW CO., CANADA.

An accidental fracture of a large orthoclase crystal from this locality revealed the fact that the crystal had entirely surrounded a pyroxene crystal. A section was cut just above this fracture and approximately parallel to the basal cleavage of the orthoclase crystal. This showed that the c axis of the pyroxene crystal was nearly at right-angles to the clino pinacoid cleavage lines of the orthoclase crystal. The pyroxene section was nearly parallel to the clino pinacoid as a large extinction angle of 44° was noticed. The line of junction was sharp and very irregular; a trace of decomposition being only noticed at one spot along the line of contact. The further fact was revealed that the orthoclase crystal was not a simple one, but was made up of intergrowths of orthoclase crystals. The surfaces of the orthoclase crystal were very much corroded. Decomposition of the pyroxene crystal was also noticed.
—*Mineralogical Laboratory, Columbia College.*

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PRESENT CONDITION OF THE MECHANICAL PREPARATION OF ORES IN SAXONY, HARTZ AND RHENISH PRUSSIA.

BY M. MAURICE BELLOM.

(Continued from p. 238.)

Schmitt-Manderbach Spiral Trommel, continued. — The same figures show at T the hand-picking table which takes the refuse of the first screen plate which is emptied thereon from the chute *c*.

The slimes are separated before the ore is sent to the apparatus.

This separation is unnecessary in trommels, because in this case, the screening requires a large quantity of water, both for the introduction of the ore into the trommel and also for the sizing of the ore therein. The disadvantages resulting from the presence of slimes is relatively far less in trommels, by reason of the large quantity of water required, whether slimes are present or not.

On the contrary, the Schmitt apparatus consuming much less water than the trommels when the materials which it takes are not particularly muddy, it is necessary to separate the slimes from the products to be put through the apparatus. This is effected by means of a sheet-iron washing trommel A into which the materials are washed by a current of water furnished by the sprinkler B. The screen G only serves to retain the very large pieces. A channel X encircles the front end of the trommel A, limited on the inside, toward the trommel, by an annular T-iron partition, the height of which varies regularly from one point of the circumference to another. The rotation of the trommel thus presents successively at the same point a partition of variable height, and thus when the lowest segment of the partition arrives at the bottom of the wash-trommel, the upper layer of muddy water is periodically discharged into X. This muddy water which includes nearly all the slimes, flows off through the trough D. The communication between the wash-trommel A and the Schmitt apparatus, is by means of a longitudinal spout into which the material is elevated by the trommel, and through which it is conveyed to the inner perforated plate of the screen.

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In the Himmelfurst apparatus, the washing trommel is 1.200 meters long and 1.200 meters in diameter.

The constructive details of the Schmitt apparatus are as follows:

Upon the horizontal axis of rotation which rests upon two pedestals, are keyed two discs joined by a sleeve, to which are screwed two or three arms which carry the perforated plates. Each cylindrical envelope is composed of two or three segments perforated, at their four corners, by holes which allow of their being bolted to the frames carried by the arms. When the frames are put in place, a piece of U-iron is placed over the T-iron which forms the arm, which U-iron rests upon the heads of the bolts on each side of the arm. The U-irons are fastened by tension-bolts

FIG. 9. (Scale $\frac{1}{30}$.)

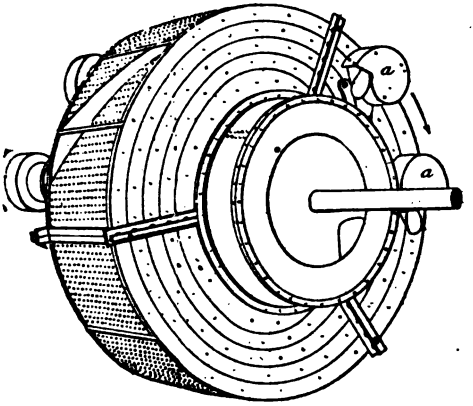
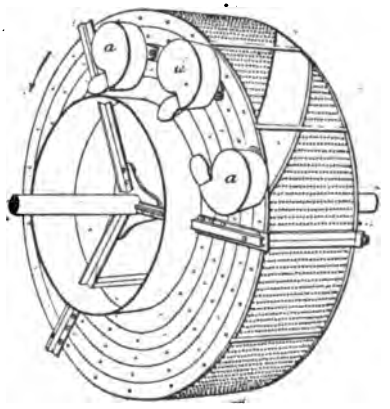


FIG. 10. (Scale $\frac{1}{30}$.)



connecting two corresponding arms. By this arrangement the apparatus can be easily taken apart and worn out plates rapidly replaced. With an apparatus of three arms and seven plates, two workmen can replace a plate in a quarter of an hour.

It is interesting to give here the results of a comparison which Mr. Schmitt has made between his apparatus and other sizing apparatus and which he has kindly sent me.

He has chosen as terms of comparison. 1st. The sizing at Immekeppel near Bensberg (Rhenish Prussia); 2d. The sizing in the Dorothea washing-house at Clausthal; 3d. The sizing in the works of Altlay near Zell-on-the-Moselle.

In the first of these dressing-works they use three trommels of successive plates (with holes of increasing diameter), from the first

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to the last trommel; in the second, five elevated trommels (with holes of decreasing diameter); in the third, a Schmitt-Manderbach apparatus with seven screen plates.

The first-named establishment treats 13 cubic meters of ore in ten hours and the second and third each treat 40 cubic meters in the same time. In order to establish a comparison, Mr. Schmitt assumes the ore to be composed of three sizes presenting the following proportions:

First size greater than 20 mm., 60 per cent.

Second size greater than 5 mm., 24 per cent.

Third size smaller than 5 mm., 16 per cent.

The work of a sizing apparatus is valuable not only according to the quantity which may be passed, but also according to the fineness and number of sizes which it is capable of furnishing.

The advantage then rests with the apparatus which, all other things being equal, will furnish per square meter of perforated plate, the greatest quantity of sized ore.

The elements to be considered then are:

1st. The amount of ore treated per minute.

2d. The composition of this ore with respect to size.

3d. The extent of surface of the various plates which the ore must pass over; in other words the quantity of ore which these plates treat per square meter per minute.

On the other hand, the difficulty of classification increases proportionally to the quantity of ore and inversely as the square of the diameters of the holes, or (disregarding the differences in size of grains of the same class), to the square of the mean diameter of the class received on a given sheet.

If, then, we denote by:

m, the volume of the refuse from a given plate per square meter of plate per minute;

n, the corresponding volume of fine stuff which passes through the same plate;

d_1, the mean diameter of the grains which make up the refuse.

d_2, that of the grains which make up the corresponding fine stuff; the production l of a square meter of the given plate may be expressed by the formula,

$$l = \frac{n}{d_1^2} + \frac{m}{d_2^2},$$

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and denoting by F_1 the surface of each plate which comes into play, the total production L of the apparatus per minute will be:

$$L = \Sigma F_1 \left(\frac{n}{d_1^2} + \frac{m}{d_2^2} \right).$$

Upon the preceding considerations Mr. Schmitt has based the following table (p. 334):

In order to compare these three works from the point of view of speed of production, the mean value of the output of a square meter of plate must be considered, which gives:

Trommels with successive plates.	Elevated trommels.	Schmidt-Manderbach apparatus.
167	233	709
19	39	100
1	2	5

The total outputs are 2.130, 6.637, and 11.276, or as 1 : 3 : 5.

Lastly, from the point of view of expense of motive force and erection, Mr. Schmitt contends that the relative figures for the three cases considered are as 6 : 2 : 1.

The economy of motive force, which Mr. Schmitt states to be a question of experiment, may be demonstrated as follows:

Let us take a trommel of 6 successive plates and of increasing holes, passing 50 tons of ore in ten hours, at a velocity of 16–17 revolutions per minute, which gives about 1000 revolutions per hour. It will pass in one revolution a weight of ore equal to $\frac{50}{10 \times 1000} = 0.005$ tons. Now, let h be the height to which a fragment must be raised before it falls, and let α be the angle which the radius terminating in the point where the fragment leaves the plate, makes with the horizontal. Denoting by d the diameter of the trommel, we will have:

$$h = \frac{d}{2} (1 - \cos. \alpha).$$

We may assume $\alpha = 50°$, which gives:

$$h = \frac{d}{2} \times 0.358.$$

The value H of the quantity h, corresponding to a complete

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		Diameter of the holes in the Sieve.	Composition of the Ore.	Discharged over Sieve per minute.	Fine stuff passing thro' the holes.	Diameter of each Sieve.	Width of each Sieve.	Effective Surface of the Sieve.	Velocity at the Circumference.	Surface of each Sieve entering into play, per minute.	Discharged over Sieve per square met. per minute.	Fines sifted through 1 sq. meter of Sieve per minute.	Calculation of the Elements of Production of each Sieve.			Total Production of the Apparatus per minute.
		d. Millim.	Pr. cent.	M. Liters.	N. Liters.	D. Meters.	b. Meters.	F. Sq. met.	V. Meters.	F. Sq. met.	n. Liters.	m. Liters.	$\frac{n}{d_1^2}$	$\frac{m}{d_2^2}$	$\frac{n}{d_1^2}+\frac{m}{d_2^2}$	$F_1\left(\frac{n}{d_1^2}+\frac{m}{d_2^2}\right)$
Immekeppel Works. (Trommels of successive sieves). 13 cubic meters in 10 hours. 28.3 liters per minute.	1st Trommel..	17.0	11.0	2.53	7.98	0.63	0.90	1.77	0.37	20.0	0.390	0.767	0.79	7.30	8.09	161.80
		24.0	55.0	12.80	2.53	0.63	0.60	1.18	0.37	13.3	0.190	0.963	0.56	0.43	0.99	11.87
	2d Trommel...	4.3	5.0	1.16	2.30	0.58	0.90	1.65	0.37	20.0	0.115	0.284	3.15	31.95	35.10	60 20
		6.0	5.5	1.28	1.16	0.58	0.75	1.37	0.37	16.0	0,070	0 274	2.74	2 80	5.54	88.64
		8.5	6.0	1.49	1.28	0.58	0.65	1.18	0.37	14.4	0.080	0.226	1 75	1 43	3.18	12 72
		1.20	7.5	1.75	1.49	0.58	0.50	0.91	0.37	11.1	0.134	0.158	0.80	1.34	2.14	23 75
	3d Trommel...	0.75	3.0	0.69	0.23	0.47	0.90	1.02	0.37	20.0	0 011	0.109	17.65	32.39	50.04	1000.80
		1.20	4.0	0.92	0.35	0.47	0.60	0.88	0.37	13.1	0 026	0.131	12.90	26.08	39.18	521.29
		3.20	2.0	0.46	0.76	0.47	0.50	0.73	0.37	11.1	0.068	0 090	6.93	15.77	22.70	249.70
	Everything under.....	0.75	1.0	0.23				10.69 per rev.		140.0 per min.					166 92 $\frac{167}{9\times10}=1.9$	2130.77
			100.0	23.33												
Dorothé Works, at Clausthal. (Elevated Trom'els) 40 cu. m. in 10 hrs. 66.66 liters pr. min.	1st Trommel..	16.0	10.0	44.60	22.00	0.97	1.16	3.40	1.08	30	0.380	0.750	0.79	4.70	5.49	329.40
	2d "	22.0	57.0	38.00	6.60	0.97	0.59	1.80	1.08	60	0.220	1.260	0.40	0.70	1.10	33.00
	3d "	10.0	9.0	6.00	16.00	0.43	1.46	1.90	0.35	29	0.550	0.200	1,18	15.30	16.48	477.99
	4th "	6.0	8.0	5.30	10.70	0.43	1.46	1.90	0.35	29	0.360	0 180	2 81	32.50	35.31	736.97
	5th "	3.0	7.0	4.60	6.10	0.43	1.46	1.90	0.35	29	0.210	0.160	8 00	52.50	60.50	1754.50
	Everything under.....	1.5	5.0	3.46	2.70	0.43	1.46	1.90	0.35	29	0.090	0.120	24 00	90.00	114.00	3306.00
		1.5	4.0	2.70				12.80 per rev.		206 per min.					232.88 $\frac{233}{6\times10}=3.9$	6637.86
			100.0	66.66												
Altlay Dressing Works. (Schmitt-Manderbach Apparatus.) 40 cu. meters in 10 hrs. 8 revolutions per min. 66.66 liters per min.	1st Sieve....	25.0	54.0	35.96	30.70	0.77	0.55	1.65	0.32	13	2.35	2.766	1.56	16 40	17.96	233 48
	2d "	16.0	13.0	8.76	11.94	1.00	0.55	1.25	0.42	10	2.19	0.876	2.19	44.70	46.89	469.50
	3d "	10.0	9.0	5.99	15.93	1.18	0.55	1.50	0.49	12	1.36	0.499	2.80	53.20	56.00	672.00
	4th "	6.0	8.0	5.33	10.62	1.35	0.55	1.75	0.56	14	1.76	0.381	6.00	84.44	90.44	1166.16
	5th "	4.0	7.0	4.66	5.96	1.53	0.55	2.00	0.62	10	0 37	0.297	9.02	101.11	110.13	1770.88
	6th "	2,5	3.0	1.99	3.97	1.72	0.55	2.15	0.72	17	0.22	0 113	16.88	177.18	194.06	3396.35
	7th "	1.5	2.0	1.31	2.66	1.87	0.55	2.40	0.78	19	0.14	0.070	47.82	140.00	187.82	3588.58
	Under	1.5	4.0	2.66				12.70 per rev.		101 per min.					709.30 $\frac{709}{7\times10}=10.0$	11296.95
			100.0	66.66												

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revolution of the trommel, is obtained by multiplying h by the ratio $\frac{360}{50} = 7.19$. But, by reason of the inverse sliding to which the fragments are submitted by the rotation of the trommel, it is necessary to replace 7.19 by a lower coefficient such as 6.5, which gives:

$$H = \frac{d}{2} \times .358 \times 6.5 = 1.16\ d.$$

Substituting this value, the work developed by one revolution of a trommel of a diameter d, revolving at 17 revolutions per minute, will be:

$$W = 1.16 \times d \times \frac{17}{60} \times Q.$$

Q being the charge raised in a revolution. Supposing that each fragment executes 5 revolutions on each of the six trommels, we find that

$$Q = \frac{5 \times 6 \times 5}{2} = 75\ \textit{kilograms.}$$

Taking $d = 0.8$ meters, we have $W = 20$ *kilogram-meters per second.* Adding 12 kilograms to cover the other expenses, notably the distribution of water, we arrive at a value of about one-half a horse power.

Taking the case of six elevated trommels, the friction produced in the numerous wedges and in the transmission, consumes not less than 25 kilogram-meters per second, or one-third horse power, including the expenditure of motive power for distributing the water. We have thus, in this case, an expenditure of five-sixths of a horse power for the same production as in the preceding case (50 tons in 10 hours).

A Schmitt apparatus, on the contrary, gives much more favorable results. The expenditure of motive force for the operations other than the displacement of the ore inside the apparatus, is as above 12 kilogram-meters. If we assume a production of 50 tons in 10 hours, the apparatus having a diameter of 1.40 meters, and revolving at a rate of 10 revolutions per minute, the quantity passed per revolution will be:

$$Q \times \frac{50{,}000}{10 \times 60 \times 10} = 8.3\ \textit{kilograms.}$$

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We have then:

$$W = 1.16 \times d \times \frac{10}{60} \times Q.$$

$$W = 2.1 \textit{ kilogram-meters per second.}$$

Adding half of its value to this figure for safety, we get an expenditure of motive force of 3 kilogram-meters in the same circumstances where the trommel gave 20 kilogram-meters, which gives a ratio of 1 : 7 between the expenditures of motive force. The ratio of 1 : 6 given by Mr. Schmitt is thus fully justified.

Another advantage of this apparatus consists in the small proportion of fine dust which it produces, and which, although less injurious for the sorting of ore than for that of coal, is none the less the cause of actual loss.

Now, the production of fine dust is directly connected with the length of the course traversed by the ore inside the apparatus. Let us then compare the course T traversed by a fragment of ore in the various sizers giving the same number of sizes, as, for example, 7.

1st. A trommel of 7 successive plates (with holes of increasing diameter). Assume that to obtain a satisfactory sizing in this apparatus, the finest grains must make 13 revolutions and the coarsest grains 6 revolutions, which corresponds to an average of 9 revolutions of 2 meters each.

We have then:

$$T = 2 \times 9 \times 7 = 126 \textit{ meters.}$$

2d. Seven elevated trommels with decreasing holes. Consider 8 revolutions of 2 meters inside each trommel and 1 meter for each of the six intermediate chutes between the trommels.

We then have:

$$T = (2 \times 8 \times 7) + (6 \times 1 = 118 \textit{ meters.}$$

3d. Schmitt-Manderbach apparatus of 7 plates, outside diameter, 1.80 meters; inside diameter, 1 meter; the mean diameter is then 1.40 meters, and the circumference 4.40 meters.

We have then:

$$T = 4.40 \times 7 = 30.80 \textit{ meters.}$$

Comparing the first and second types of screen it appears that T

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has the same value, and it would seem immaterial which of them we compared with the Schmitt apparatus with regard to the dust which they produce. This would be a grave error. In reality, the sizing is by no means conducted in the same way in trommels with successive plates as in elevated trommels. In these last, as is shown in table given previously, the first two trommels of the series separate 75 per cent. of the total mass, whereas, in trommels with successive plates, 75 per cent. travels through through three-quarters the length of the plates. The paths followed by these 75 per cent. will then be:

1st. In the case of trommels with successive plates:

$$0.75\ T = 0.75 \times 126 = 94\ \textit{meters}.$$

2d. In the case of elevated trommels:

$$(2 \times 8 \times 2) + 1 = 33\ \textit{meters}.$$

The ratio between the weights of dust obtained in these two cases is 94:33, or 3:1 for 75 per cent. of the total mass.

Regarding the remaining 25 per cent., the presence of large fragments renders their sorting much less favorable in the case of trommels with successive plates, and, as for the first 75 per cent. of the total mass, the ratio of 3:1 may be adopted for them. This being so, it is sufficient to compare the Schmitt apparatus with a system of elevated trommels. It is thus proved that the ratio of values of T for these two sizers is as 1:4. The ratio of the weights of dust produced will then be 1:4 between the Schmitt apparatus and the series of elevated trommels, and 1:12 between the same apparatus and the trommels with successive plates.

IV.—Treatment of Grains.

(*a*) *Method of Treatment.*—Grains include all pieces superior in size to .5 millimeters. The sizing of these products is effected by screens, as described. The treatment of the various sizes is according to the principles of equivalence (Gleichfälligkeit) in jigging apparatus. The jigs are either continuous jigs or filtering jigs. The use of filtering jigs was formerly confined to the finer grains, but is now extended to grains of larger size. Thus, at Steinenbrück, grains of 14 millimeters are now treated on filtering sieves. The extreme delicacy of this method, the operation of which is

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controlled by the nature of the filtering bed, has even led to the simultaneous employment of the continuous and the filtering discharge in the same machine. The application of this method has just been tried at Laurenburg under the following conditions: Grains of from 3 to 15 millimeters in size are treated upon a jig with screens of 8 millimeters of square mesh. This jig retains all the products above that size, which subsequently form a filtering bed, through which the products of a smaller size undergo concentration before reaching the sieve, through the holes of which they pass. In the same works they jig, upon a sieve of 1 millimeter, products 3 millimeters and less. Thus they are enabled at Laurenburg to increase the product of the apparatus, and at the same time make two jigs do the work of four, viz., of two filtering jigs for products less than 8 millimeters in the one case and less than 1 millimeter in the other, and two continuous jigs for the products coarser than these figures.

With regard to continuous jigs, the only innovation worthy of note is in the number of sieves used for the treatment of a given kind of product. If, for example, it is required to treat upon a continuous jig a material containing two useful minerals, recourse is had to a screen of four sieves, the first of which retains the heaviest product, the third the lightest, the second a mixture of these two sorts, the fourth a mixture of the lighter mineral and gangue, the overflow from the last compartment being clean gangue. For this plan, which is the one generally adopted, they have recently substituted at Ems continuous jigs with but three screens. The first gives the heavier mineral, the second a mixture of the light and the heavy minerals, and the third a mixture of light mineral with gangue. The product overflowing from the last compartment is clean gangue, as above. At first sight this method seems to be less advantageous than the preceding, inasmuch as, instead of having the two finished products furnished by the first and third screen in the first case, they can obtain but one finished product in the second case; that is to say, the one from the first screen. This is not so; for by giving a sufficient number of strokes to the piston only the quantity of waste admissible in the smelting operation is left upon the third screen. There has been thus effected not only a simplification in the apparatus by the suppression of the fourth screen, but also a reduced number of products to be rejigged from two in the four-sieved jig (pro-

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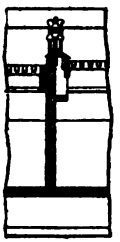
ducts from the second and fourth screens) to one in the three-sieved jig (the products from the second screen only).

(*b*) *Apparatus.*—The construction of the jigs shows but few improvements. There is, however, a tendency toward the abandonment of complicated arrangements, of which the jig at Bleyberg is an example. The discharge of the products in continuous sieves is effected either by means of a bell shaped tube analogous to that of the Moresnet jig, or by means of a slot across the end of the sieve. The adjustment of this opening is effected by means of a screw of the type adopted at Clausthal and at Lautenthal (Fig. 11).

At these works the method of discharge is varied to suit the special conditions in each case. Thus, in the latest models of jigs, a bell-shaped pipe discharge is used for the first sieve in order to avoid a too rapid flow, and, consequently, an imperfect jigging of

FIG. 11. (Scale $\frac{1}{10}$.)



the products at their entrance into the apparatus; the use of the slot, which does not by any means give to the work the same uniformity as the bell-shaped pipe, does not present the same inconveniences for the subsequent sieves as it does for the first one, by reason of the reduced speed with which the materials flow from the first to the other compartments.

Lastly, it is necessary to note an arrangement adopted at Ems in the discharge trough from the last sieve. The overflow, before going to the waste dumps, passes through a small apparatus with an ascending current on a system peculiar to Ems, which will be described later on. This apparatus, consisting of a single box, collects a rich product.

V.—TREATMENT OF THE SANDS.

(*a*) *Method of Treatment.*—The treatment of the sands (grains varying in size from 0.50 millimeters to 0.25 millimeters) consists of a sizing followed by a sorting according to specific gravity.

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A. Sizing.—Sizing has for its object, first, to separate products inferior to 0.25 millimeters or slimes; second, to divide the sands into a number of sizes It is sometimes done in a trommel, as, for example, in Hartz. However, this is an exceptional case, and the sizing in trommels of sands less than .50 millimeters is generally only a part of the sizing of coarser material in the same apparatus. The treatment is commonly effected in apparatus with an ascending current of water. This type of apparatus has customarily been considered as founded on the principle of equal falling grains, but is nevertheless used by the German engineers for sizing and preparing the material for the different forms of sorting apparatus, which will be discussed later. To this type of sizing apparatus these engineers refer the *spitzkasten*, the Ems "*sandsortiv apparat*," the Meinicke "*sandsortiv apparat*," the Weiss "*spitzgerinne*," and the Steinenbrück "*classificateur*."

B. Sorting.—The products of the above forms of apparatus are submitted to a sorting by specific gravity either on bump sieves (*tamis à secousses*), in filtering jigs, in German buddles (*caissons allemand*), or, lastly, upon tables.

The principle of bump sieves is connected with an idea so primitive that it will suffice simply to mention its existence; it is, however, interesting to note, in the works at Himmelfahrt (Saxony), a system of three bump sieves which treat successfully the largest sizes of stamped material separated in an ordinary spitzkasten.

The German buddle (*caisson allemand*) is also a very antique apparatus, and is to be found only in the Hartz, where it survives in spite of the large amount of hand labor which it requires; the perfect separation effected in the hands of the skilled workmen of that region suffices to explain the favor which this apparatus still enjoys.

Filtering jigs are the type *par excellence* for this work, and are distinguished by their flexibility and the ease with which they are regulated. It is proper to note here the apparatus designed at Mechernich, under the name of *heberwäsche*. This apparatus, which has been described often, merits mention as regards its application and use, which have heretofore been studied far less closely than the details of its construction. It will be seen later on, in the description of the method of treatment at Mechernich, that this apparatus is used in combination with the spitzkasten in a complete series of successive retreatments through these two kinds

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of separators. This treatment, which precedes the treatment upon table, appears illogical in considering the essentially distinct character of the spitzkasten on the one hand and the *heberwäsche* on the other, the first being rather a sizing apparatus and the second an apparatus for sorting by specific gravity. But it must not be forgotten that the peculiar nature of the ore treated at Mechernich justifies the complications and apparent anomalies of the methods there employed. The combination of the work of the *heberwäsche* with that of filtering sieves, which belong to the same class of separators, is, on the contrary, perfectly logical. However, the *heberwäsche* is reserved for the treatment of sands, and is not applied to slimes, which, after being divided into a number of classes by a passage through the spitzkasten, are treated either on round buddles, Rittinger tables, or on revolving tables, a part of the intermediate products of which is finally washed on the round buddles.

Washing tables, considered as apparatus for sand, and not as apparatus for slimes, are represented by the end-bump-tables, the Rittinger tables and the round buddles. The end-bump-tables, in spite of their defects, are still in favor, and are to be found in the plant recently constructed at Ems. The German engineers realize, it is true, that the capacity of these tables is less than that of filtering jigs, that the expense of erection and the consumption of power is greater, and that their management must be entrusted to more experienced workmen than would be necessary for filtering jigs; but they consider these disadvantages to be largely offset by the following considerations: The results of the treatment upon tables depends less upon the perfection of the preliminary sizing than in the case of jigs.

2. The passage of the products through the filtering bed of the jig produces a greater quantity of dust than at first would be supposed. The loss which thus results constitutes a real disadvantage for the jigs as compared with the tables upon which pulverization cannot occur. Regarding round buddles there is a diversity of opinion in Germany. At Ems it is contended that the round buddle is applicable to coarse sands only, and that, applied either to slimes or to fine sands (about 0.25 millimeters), the losses are notable. Moreover, these losses, they add, will be always greater in round buddles than on bump-tables or filtering jigs. The engineers of Ems, however, do not compare the preceding tables or

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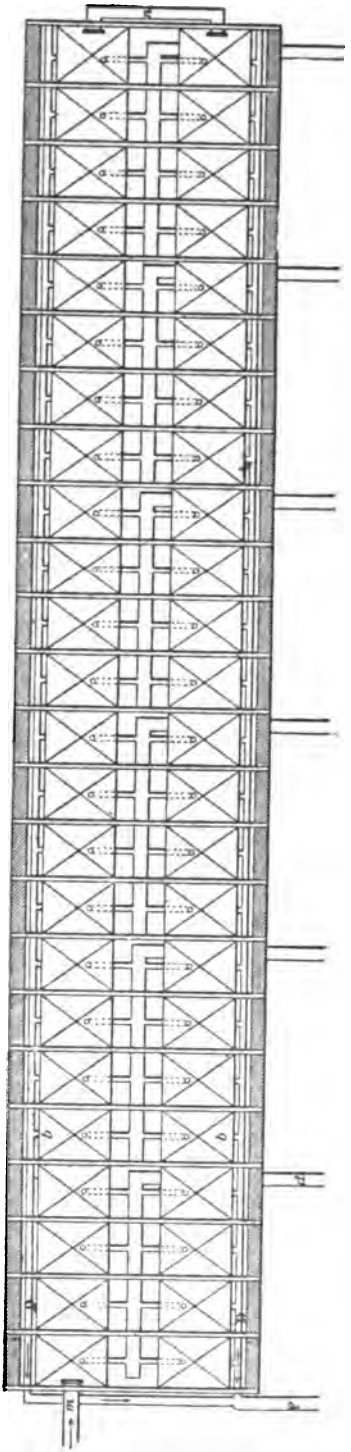

FIG. 12. (Scale $\frac{1}{200}$.)

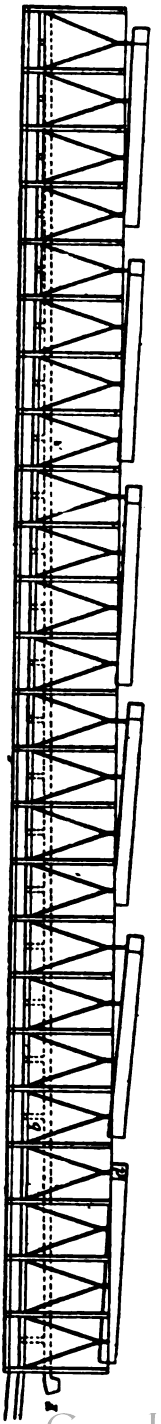

FIG. 13. (Scale $\frac{1}{200}$.)

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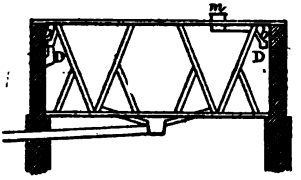
filtering sieves with the Rittinger tables, which they reserve exclusively for the treatment of slimes. The works at Laurenburg likewise furnish an example of the use of longitudinal bump-tables.

These opinions are not shared by other engineers, as is proved by the presence of round buddles in the recently erected plant at Weissshaft, in which not a bump-table is used.

FIG. 14. (Scale $\frac{1}{200}$.)

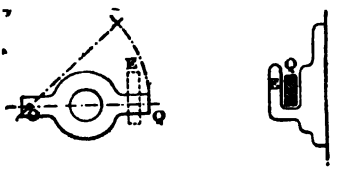


The opinions upon sorting of sands which prevail in the Hartz and Saxony conform exactly to those laid down in the treatises on ore dressing. The important innovation to be noted in these two regions is the use of the Meinicke classifier, which will be described later.

It is only in Saxony that the Rittinger table is used for the treatment of sands, and that in the Hartz this apparatus in general receives only the products already treated on filtering sieves.

(*b*) *Apparatus.*—I will limit myself to describing the apparatus which by reason of improvements or by their novelty invite attention.

FIGS. 15 and 16. (Scale $\frac{1}{100}$.)



1°. *Spitzkasten.*—The most recent type of spitzkasten is that which was constructed in 1887 at Friedrichssegen. This apparatus is shown on plan in Fig. 12, while Figs. 13 and 14 give longitudinal and transverse sections respectively. It is composed of two parallel ranges of twenty-four compartments each. The sands to be separated enter at *m* traverse the whole of the first range of twenty-four compartments, then pass by the pipe *n* from the first to

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the second range. The products deposited in four successive compartments are united in a duct *c* which is prolonged by the trough *d*. The water cleared by the deposition of these products flows off from each compartment through the duct *b*, except that from the first four compartments which contains too much sand. The ducts *b* which discharge at 95 millimeters below the upper side of the spitzkasten, meet a duct D on each half of the apparatus discharging itself into a trough F which carries the water to the washing tables. A series of openings on the long sides of the apparatus and in the face of each compartment permits the taking of samples to determine the nature of the products deposited. Each of these openings is normally closed by a cast-iron disc (see Figs 15 and 16), movable about the point O of the wall of the spitzkasten and provided with an end Q used as a handle which in the closed position is engaged in the stirrup E.

2°. *The Sand-sortivapparat* (*sand classifier*) *of Ems.*—This is a modified spitzkasten with an ascending current. In the old form of spitzkasten, where the ascending current of water is produced by a vertical pipe terminating near the discharge opening, there is produced in each box a sort of "floating cloud," the disadvantages of which have been early shown. A remedy has been sought in the equally old trough classifier (*spitzlutte*) with a continuous discharge-slit at the bottom. This trough is placed inside a rectangular wooden box in which the ascending current of water is introduced. The disadvantages arising from the discontinuity of pointed boxes is thus avoided, and, if the apparatus is of sufficient dimensions each division of grains will seek a section where the velocity permits its descent and deposition.

The objection to this is its cumbersone dimensions which have been reduced in the apparatus at Ems, retaining the same principle.

The Ems sand classifier, Figs. 17, 18 and 19 consists of a series of boxes equal in number to the number of divisions which are to be obtained. Each of these boxes is larger than the preceding one.

A longitudinal section of an apparatus of four boxes is shown in Fig. 17. Fig. 18 is a plan, and Fig. 19 a transverse section, *a b*, and *c d* are the two inclined walls corresponding to the sides of the trough classifier; *b c* is the slit for the ascending current produced by the pipes I discharging at O into the box below the trough *a*, *b*, *c*, *d*. The products are deposited at the discharge *f*

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into the troughs g in each box. The apparatus can treat 800 liters per minute. The cross-section of any element is double that of the one immediately preceding it, which corresponds to a ratio between the dimensions of homologous parts equal to $\sqrt{2} = 1.414$.

3°. *The Meinicke Sand Classifier* (Figs. 20–26) consists of a

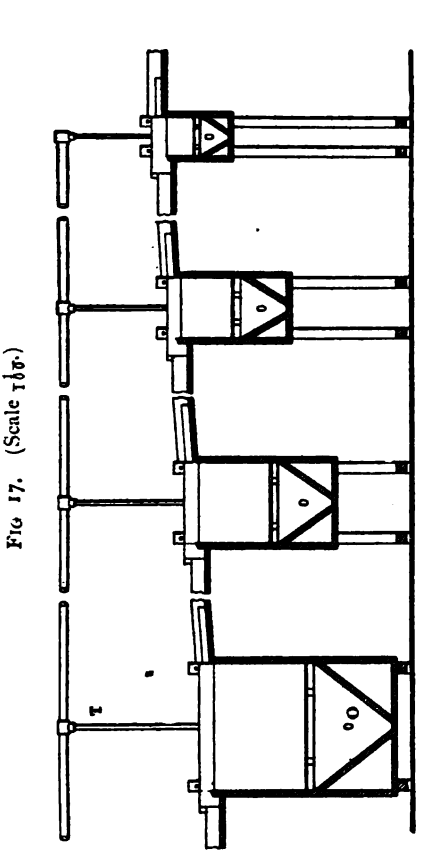

Fig. 17. (Scale $\frac{1}{10}$.)

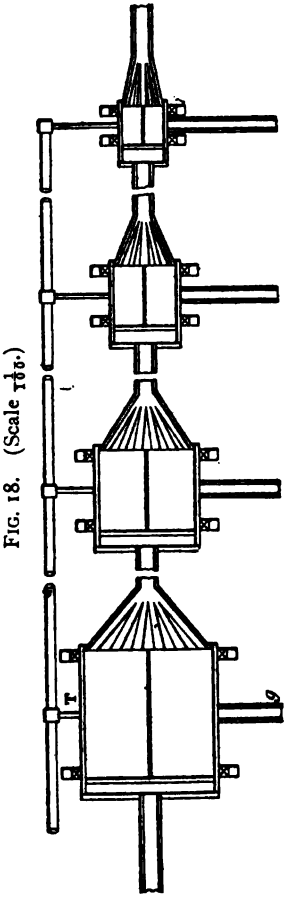

Fig. 18. (Scale $\frac{1}{10}$.)

The Ems Sand Classifier.

wooden box A in which the ascending current is produced by means of a pipe R. The sands to be treated enter at M and the lighter portion is carried off by the trough N. The heavier products fall into the box A, and are submitted to a sorting by the ascending current of water. In the original type, which dates

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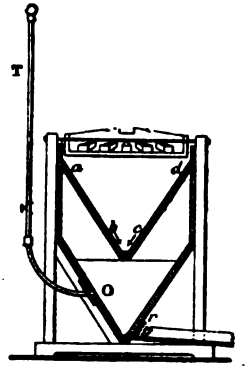
from 1887 (Figs. 20, 21, 22, 23), the wash water was supplied by the cocks R_1, R_2, R_3, R_4. The current produced by each cock, after having passed the shoulders shown at p_1, p_2, p_3, p_4, meets the

FIG. 19. (Scale $\frac{1}{100}$.)



products which descend at q_1, q_2, q_3, q_4. The duct d, regulated by the gate δ, allows the lighter portions which have descended into B to be united with the portions directly carried at N.

FIG. 20.

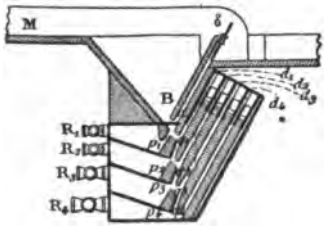


FIG. 21.

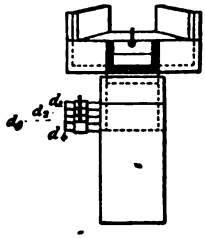


FIG. 22.

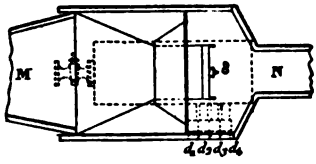
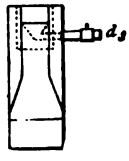


FIG. 22.



Original Meinicke Sand Classifier.

The old construction has been modified in the manner of discharging the products, the cocks R_1, R_2, R_3 and the slits q_1, q_2, q_3 have been suppressed.

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The modified apparatus is shown in Figs. 24, 25 and 26, of which Fig. 24 shows a vertical projection, Fig. 25 a vertical projection on a plane perpendicular to the preceding one and Fig. 26 a horizontal projection, the letters having the same significance as those in Figs. 20, 21, 22 and 23, *R* being the single pipe by which the water for washing enters. The elements of construction and details of operation are given in by the following table (p. 348).

FIG. 24.

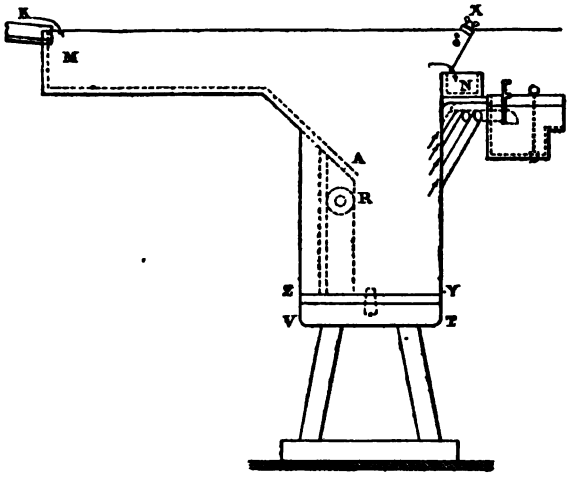


FIG. 25.

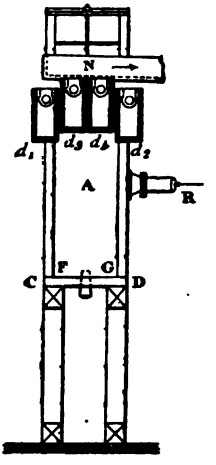
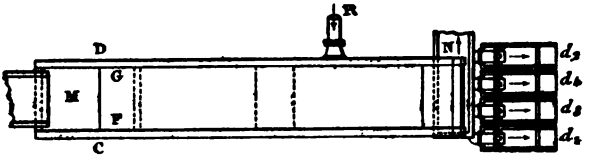


FIG. 26.



The Modified Meinicke Sand Classifier.

By calling

b the inside width $F\,G$ of the box A.

b_1 the outside width $C\,D$ of the box A.

L_1 the length $K\,X$.

L_2 the horizontal dimensions $Z\,Y$ of the box A.

h_1 the difference in level between $K\,X$ and the bottom of pipe d_1 at the point where it leaves the apparatus.

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h_2 the difference in level between $K\,X$ and the bottom of pipe d_2 at the point where it leaves the apparatus.

h_3 the difference in level between $K\,X$ and the bottom of pipe d_3 at the point where it leaves the apparatus.

h_4 the difference in level between $K\,X$ and the bottom of pipe d_4 at the point where it leaves the apparatus.

h_5 the difference in level between $K\,X$ and the bottom of pipe N.

H the difference in level between $K\,X$ and $V\,I$.

The apparatus treats ten liters per minute per centimeter of inside width, the water containing 6 to 8 per cent. in volume of solid matter.

Value of b in millimeters.....	250–350		350–700		700–1000	
" L_1 "	2250		2250		2250	
" L_2 "	750		900		1050	
" H "	1550		1730		2050	
" b_1 "	$b+80$		$b+100$		$b+100$	
Dimensions of grains in mm...	.25	2.5	.25	2.5	.25	2.5
h_1.....	550	660	600	710	700	760
h_2.....	550	610	600	660	700	760
h_3.....	500	560	500	560	600	660
h_4.....	500	510	500	560	600	610
h_5.....	400	400	400	400	450	450

This apparatus, which is in actual use at Churprinz (Saxony), at Clausthal and at Lauthenthal (Hartz) under conditions which will be described later, differs essentially from the sand sorting apparatus of Ems in that the influence of the diminution of the washing inside the apparatus does not enter into the discussion. In sorters where this diminution occurs, when the size which is first deposited is the size which is largest and heaviest, and the water for washing is principally used to separate from the size which is deposited and to unite with the portions carried by the current, the finer stuff; the water for washing tends to increase the volume of the washings, and consequently diminish its degree of concentration. In the Meinicke apparatus, on the contrary, the lightest division is separated first and the water is only introduced once into the middle of the washings. Thus a more perfect sort-

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ing is obtained together with an economy of water and the useless dilution of the washings is avoided.*

4° *Round Buddle.*—The only improvement to be noted in this apparatus consists in the convex and slightly barrel-shaped form given to the round buddles in the stamp mill ("Pochwerk") of the Clausthal dressing works. This construction serves to retain more easily the galeniferous products which accumulate at the upper part of the table, while the washing away of the blende which is collected at the periphery of the apparatus is accelerated by the greater inclination which the washing table presents at that zone.

NOTES ON THE LOWER COAL MEASURES OF WESTERN CLEARFIELD COUNTY, PENNSYLVANIA.

By J. F. KEMP.

The publication of Bulletin 65, of the United States Geological Survey, by I. C. White on the "Stratigraphy of the Bituminous Coal-Field in Pennsylvania, Ohio and West Virginia," gave to the public the most important number of this series of Bulletins. It has served not only the useful purpose of placing at general disposal an indispensable book of reference, but in the citation of geological sections throughout the region, it has also indicated those areas which as yet lack them, and which need exploration and record. To fill up such a gap in an important district is the object of these notes.

Clearfield county lies in central Pennsylvania, west of the main folds of the Alleghenies, and in the eastern edge of the bituminous coal-fields. The drainage, however, still flows eastward mainly through the west branch of the Susquehanna. The First Bituminous Coal Basin is on its eastern boundary, and in it the coal has long been mined near Houtzdale, Osceola, and Phillipsburg,

* It must be remembered that the application of this apparatus in the Clausthal works has not given the results expected. The reason must be sought in the nature of the sands treated at Clausthal. The largest size furnished by this apparatus contains too large a proportion of large grains which roll on the washing tables with a velocity that excludes all methodical sorting. In the Spitzkasten, on the contrary, the quantity of slimes mingled with the large grains is sufficiently great to retard the movement of these grains upon the washing surface.

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and shipped eastward especially for steaming purposes. The Lower Freeport has been the most highly esteemed seam. The First Anticlinal separates this from the Second Basin which contains the flourishing towns of Clearfield and Curwensville, and in whose trough flows the west branch of the Susquehanna for much of its course. The river has the Lower Productive Measures for its bed above the small town of Bellville and for about two miles below, but at a crossing known as the Hoyt Bridge it passes to the Pottsville Conglomerate on which it continues for the remainder of its course. These details are somewhat different from the map by Dr. Chance—which accompanies Report 47 of the Pennsylvania Survey, late drilling and prospecting having furnished new data.

Professor White gives sections of the Lower Productive Measures near the town of Clearfield where they are found on the hills, and also others in Jefferson and Indiana counties far to the west. To these may now be added the following which are from fifteen to twenty miles from his nearest one, and in a region lately opened up by new railways. The axis of the synclinal trough pitches gradually southwestward so that two miles above the Hoyt Bridge the river is a hundred feet or so over the top of the Pottsville Conglomerate, which at Lumber City, two miles below the Hoyt Bridge, is about forty feet above the river. On the Conglomerate, which is here a coarse sandstone, there lies the fire clay so much used at Woodland. No complete section of it is well shown, but the float all along this stretch proves its presence, and local reports assign it a thickness of 8 to 12 feet, which is probably greatly exaggerated. Over this comes the A coal-seam, a thin valueless bed, but showing in a prospect just above the Hoyt Bridge. It was dug years ago, is now fallen shut and no reliable data can be obtained, except that it was poor. Above the coal lies the Clarion sandstone, filling an interval of seventy feet before the next coal-seam is met. The sandstone is massive and affords huge blocks by its weathering. It contains about 90 per cent. silica. It cuts out the Clarion coal-seam as no traces of this appear. No evidence of the Ferriferous limestone was met in the same interval.

Over this comes the B or Lower Kittanning seam. It is a double one, and affords from 2 feet 6 inches to 4 feet in the lower bench. Between this and the upper there are from 4 to 10 feet of slate, and then the upper, bench of 3 to 4 feet of coal. These

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data were gathered from several drill-holes near Bellville, and from Passmore's country bank a mile below the town. The latter is opened on what is doubtless the upper bench. Forty inches of coal are exposed, with a two-inch mining slate midway. An average sample from several tons on the tipple afforded:

Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.
0.79	27.76	60.96	10.48	2.18

The coal gives a fairly firm, dark gray coke. The seam thus affords a coking coal, rather high in ash, and sulphurous. Washed samples from a number of drill-holes in other parts of the neighborhood yielded much less ash for the upper bench than the lower, but never less than 8 per cent. for the former.

About thirty feet over the B seam at Passmore's, a bench shows which yielded a 2-foot seam to an old-time prospect. It appears across the river in the Beech Creek railway cut at two feet, and is reported from drill-holes up-stream at one foot. This is the Middle Kittanning or C seam. Some 60 feet over this at Passmore's, the Upper Kittanning or C seam has been opened by Eli Passmore. The prospect shows 27 inches of coal, with the upper part bony. Very bituminous, black slates are below it, which in drill-holes with the oil rig, have given exaggerated ideas of its thicknesss..

Above this seam in drill-holes on both sides of the river an unprecedented interval has been found before the D seam is met.. Although the interval is placed by Chance as in general 42 to 50 feet (Report, H 7, p 27), the drills found no coal for over 130 feet, nor anything that would take its place. This great interval brings up the total thickness of the Lower Productive Measures to a very large figure. North of the river the D or Lower Freeport is mined at Frank Johnson's, with coal, 34 inches; slate, 2 inches; coal, 6 inches. The coal is clean and handsome, and afforded on analysis of a sample from the tipple:

Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.
0.99	27.73	65.99	5.08	1.38

The coke is dark, silvery, and firm. A sample all across the seam gave 5.4 per cent. ash. Further north the seam increases to 4 feet, and still further, at the Miller opening, Pennville, where it is mined and shipped, it has 6 feet. There are two mining slates,

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1 foot and 2 feet from the roof respectively. A sample from five car-loads yielded 5 per cent. ash. This is the best coal of the region. South of the river drill-holes report it at 3 feet, and at a very shallow prospect, still in smut, it gave 26 inches, whose solid coal afforded 5.64 per cent. ash.

About 40 feet above the D, at Frank Johnson's, is the D′ or Upper Freeport, with a bed of limestone below it. The coal is said to be 28 to 32 inches. Further north, at the Miller opening, Pennville, the interval is 15 to 20 feet, and the D′ seam is mined at 33 inches. A sample from a pile of 50 tons gave 7 per cent. ash. The coal is a handsome one in appearance. South of the river it is thinner, showing about 2 feet in the holes.

In general, the measures pitch with the axis of the trough to the southwest quite sharply. The bottom of the syncline is probably a little south of the river, and there are some minor rolls and irregularities.

GENERALIZED SECTION.

Upper Freeport or E seam,	24 to 33 inches.
Interval with limestone,	15 to 40 feet.
Lower Freeport or D seam,	3 to 6 feet.
Interval,	130 feet plus.
Upper Kittanning or C′ seam,	27 inches.
Interval,	60 feet.
Middle Kittanning or C seam,	12 to 24 inches.
Interval,	30 feet.
Lower Kittanning or B seam—upper bench,	36 to 48 inches.
" " slate,	4 to 10 feet.
" " lower bench,	30 to 48 inches.
Sandstone (Clarion),	70 feet.
Brookville or A seam,	
Fire-clay,	
Pottsville Conglomerate,	
Total for Lower Productive Measures,	323 to 352 feet plus.

The Second Anticlinal separates the foregoing basin from the Third or Reynoldsville Basin. This is the scene of great development to-day, and several large companies are in full operation, which have been inaugurated since Dr. Chance's report in 1883. Exceptionally fine steaming coals are afforded. The following section was compiled near Luthersburg, in the eastern edge of the basin, and is based upon repeated aneroid readings for the seams on the surface and on drill records, to which I have had access for the portion below:

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Mahoning Sandstone on the Hill-tops:	
Upper Freeport or E seam (locally called the Brisbin),	6 feet.
Interval with limestone,	40 feet.
Middle Freeport or D′ seam—smut,	20 inches.
Interval,	20 feet.
Lower Freeport or D seam—smut,	28 inches.
Interval,	30 feet.
Upper Kittanning or C′ seam (locally called the Wet vein)—smut,	36 inches.
Interval,	40 feet.
Middle Kittanning or C seam (locally called the Pot-shop)—smut,	37 inches.
Interval (including surface of ground),	50 feet.
Place of Lower Kittanning or B seam, shown by black slate in drill hole,	3 inches.
Clarion sandstone,	37 feet.
Slates, shales, etc.,	67 feet.
Place of Brookville or A seam—coal,	few inches.
Pottsville Conglomerate,	175 feet.
Red Mauch Chunk shale, shown by drill,	
Total for Lower Productive Measures,	266.
Pottsville Conglomerate,	175.

Several analyses gave the following results:

	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.
Middle Kittanning or C seam, outcrop	2.29	28.33	63.15	6.22	0.55
Upper Kittanning or C′ seam, outcrop	1.03	29.30	61.20	8.46	1 51
Lower Freeport or D seam, outcrop	7.42	29.36	54 61	8.69	0.42
Upper Freeport or E seam, Brisbin mine	1.18	30.29	60.56	7.95	1.80

All the measures dip toward the northwest at about 150 feet to the mile, and a great cover of Lower Barren Measures soon comes in over them. There are some minor rolls in addition to the general dip.

What drilling has been done to the north in Union township has given slight encouragement. Where present, the coals are thin.

The analyses recorded above were kindly and gratuitously made for the writer by Prof. L. M. Dennis, of Cornell University, to whose aid much of the value of the record is thus due.

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THE OLD TELEGRAPH MINE, BINGHAM CAÑON, UTAH.

By CLARENCE FENNER.

THE vein on which the Old Telegraph mine is located is the most important one in Bingham Cañon. There are numerous other veins, from some of which large quantities of ore have been taken, but none of these equal the Old Telegraph in size or in value of ore produced.

Northeast of the Old Telegraph property is the Brooklyn mine, and southwest are the Jordan and Galena mines. All the indications are that they belong to the same lode. The Brooklyn mine has been extensively worked, but is now almost closed down. The Jordan and Galena have also produced much ore, and are still in active operation. There are other mines which are supposed to be on this same vein, and altogether the vein can be traced for three or four miles.

It is probably a true fissure-vein, but in most cases follows the bedding-planes of the adjacent stratified rocks. These stratified rocks are limestone or quartzite. The limestone is not of frequent occurrence, but there is one bed forming the foot-wall of the vein in places. It is white and crystalline, and resembles marble. The thickness is not shown. The quartzite is of two kinds: First, ordinary white quartzite; and second, a cherty variety, often of a glassy or semi-opaline appearance.

The stratification of the beds is quite apparent. The dip is at about 30° from the horizontal, and in a direction somewhat west of north. The strike is northeast and southwest.

The workings of the mine are situated on the two sides of Bear Gulch. This gulch is the upper extension of Bingham Cañon. It has an approximately north and south direction. Lower down the gulch, toward the town of Bingham, the dip of the strata becomes less, and at the town they lie in nearly horizontal beds.

Besides the stratified rocks, there are numerous dykes of igneous material which have broken through. These dykes are sometimes granite and sometimes a white quartz-porphyry. They also appear to follow more or less closely the planes of the stratified rocks, but I have not had an opportunity to determine this carefully.

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The walls of the vein differ in various parts of the mine, showing that, in places, the original fissure broke across the strata. There is another fact which tends to confirm this. There are numerous places in the mine where masses of waste (horses) are encountered. In many cases this waste is the ordinary white quartzite, and as this often forms the hanging wall its presence in the vein is easily accounted for. But almost as frequently the waste is found to be the cherty quartzite. I have not seen any place where this forms the wall of the vein, but it must have done so at a higher elevation than the present surface, otherwise it would be difficult to explain the presence of this material with the ore. The outcrop of a bed of this chert is found not much higher than the vein, and the same rock is said to occur below in the section. Which of these beds the fissure formerly followed in its upper portions is not definitely shown, but it probably reached the higher stratum.

The width of the vein is very great, probably 150 feet. measured in a direction perpendicular to the walls. In the upper workings, oxidized ores are found. They consist largely of lead carbonate, carrying silver up to about 16 ounces, a little gold, and lead up to 60 per cent. In places, the value may run higher than these figures, but the average is considerably lower. Silicious material is generally mingled to some amount with the carbonate. The carbonate is found in chambers separated from each other by waste or by the so-called quartz ore. The latter is probably the residue of the original ore where this consisted largely of iron pyrites with a quartz gangue. The iron sulphide was oxidized and partially leached out, leaving the insoluble silica. That such was the case is quite evident. The quartz is very porous, the holes being often of the shape of pyrite crystals. It is, in fact, the silicious skeleton of the original vein-filling. It may be so broken up, however, that the former structure is not so evident. Small amounts of pyrite are found in many places in the quartz. The quartz ore may carry as much gold and silver as the carbonate, but because of the lack of lead and the presence of such an excess of silica, it has not been extensively mined.

In the lower tunnels of the mine no more oxidized ores are found, but the original sulphides are still preserved. The transition from one to the other is quite gradual in some places, but in other places the dividing-line is distinct. For instance, in one

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portion of the Roman Empire workings there is a body of base ore consisting of iron pyrites and galena, and carrying some zinc. It is mixed with carbonate, and between this and the roof of waste there is a narrow streak of good carbonate, while below unaltered pyrite is found. In the contract tunnel carbonate ore occurs, but here and there through it there are boulders of unaltered pyrites surrounded by a shell of iron oxide. These boulders were especially frequent near the bottom of the chamber that was worked, and would seem to indicate the presence of a body of unaltered pyrites a little below. In another part of the Roman Empire tunnel a large body of pyrites has been found that passes abruptly into the porous quartz. There does not seem to be any intermediate stage, but in the space of a quarter of an inch we find quartz above and unaltered pyrites below. Curiously enough, the quartz ore is said to be found sometimes both above and below the pyrites. It seems that some portions of the body must have been more easily oxidized than others, perhaps due to a larger or smaller proportion of pyrite to quartz.

The Grecian Bend tunnel is the only one in which only sulphides are found (excepting the Proctor, which has been little developed). The workings in the Grecian Bend are of large extent, and we have the best opportunity for studying the unoxidized ore. Considerable galena has been found. Two or three chambers of this have been taken out but most of the ore is iron pyrites, and this has not been found rich enough in gold or silver to work for these alone. The galena is apt to carry considerable ZnS and is usually accompanied by more or less FeS_2. The bodies of purer pyrites probably carry a little copper in most cases. The copper may rise to 8–10 per cent. or more and the pyrite is then taken out as a copper ore. The presence of copper is indicated by a blue stain that comes out on the walls after the drifts have been opened for some time. The pyrites carry arsenic also.

Sometimes the pyrites are rather loose and granular while in other cases they are so hard and compact that a heavy blow with a hammer will fail to break a piece. The latter variety is usually fine-grained and steely. Most of the gangue of both the pyrites and the galena is crystalline quartz. It will vary in quantity from almost nothing, up to 50 per cent. or more. No large body is found, however, in which the quartz is in excess of the sulphides. Usually the amount of quartz is less than 20 per cent. This quartz

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is hard and crystalline, but in some places pyrite is found mixed with a loose, sandy material consisting mostly of silica. This is probably a sediment that was deposited in the solutions filling the fissure, at the same time as the pyrites, and composed of ground-up wall rock. Then, too, there are bodies of waste which are of a clayey nature and often have a banded or stratified structure. Again, the waste may consist largely of angular fragments of rock. The material of which these mechanical deposits are composed must have resulted from the opening of the fissure and the movement of the walls.

When the fissure opened there was probably a great splitting of the walls on both sides and large blocks of rock fell into the opening. These would not rest on the foot-wall but would slide down until the angle of inclination became less or until they met some obstacle. The fact seems to be that the whole opening became filled with piled-up masses of rock. As the pieces were of such great size and as they were of a rather slab-like shape, the spaces left between them would be large. About two-thirds of the vein-filling consists of these masses of waste.

In the interstices between the masses of country-rock the ore was deposited. Necessarily the deposits would be extremely irregular in shape and size, and in mining there would be nothing to indicate where a body of ore might be expected. A drift might be run for 100 feet through waste and pass within a short distance of ore without anything to show its presence. The origin of the mineral-bearing solutions, whether from below or from the sides, is uncertain. That the whole fissure was filled by the waters is shown by the stratification of the finer sediments as mentioned above. So vast a crack as this seems to have been could not but furnish a water-way of no inconsiderable moment. It would appear as if the up-flow used the vein cavity as something of a reservoir, whence it issued as a series of springs along the outcrop, and that in these slowly circulating waters the ores were deposited and the attrition débris, with, perhaps, some residual materials left by solution and removal of limestone, was given the stratified character above referred to. The later deposited ore would, however, be free from this mechanical intermixture, but their contents of silica supplied the quartz gangue. The solutions varied from place to place or time to time, because we find pyrite at one point and a little further on the same level, galena.

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After the filling of the vein the mineral in the upper portions became oxidized. Where galena was the principal constituent lead sulphate and carbonate formed, and being insoluble, remained. Where the ore consisted of pyrites it was oxidized. A portion was carried away as sulphate, and another portion left as Fe_2O_3. The quartz gangue was left. In a few cases native sulphur is found which has doubtless resulted from decomposition in the presence of organic matter. Since the filling of the fissure there have been movements of the ground as is shown by occasional slickensides both in the waste and in the ore.

The Old Telegraph mine has produced a large amount of silver-lead ore. Now, however, little work is being done. Most of the ore that is taken out is mined by leasers, who pay to the company a certain percentage of the value of the ore. There is no reason to doubt that bodies of galena would be found by prospecting at lower depths.

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ABSTRACTS.

Analytical Chemistry, by E. Waller, Ph.D.

Nitroso-β-Naphthol in Quantitative Analysis. Von Knorre (*Zts. Angew. Chem.*, 1893, 264). The reagent in an acetic acid solution precipitates Co, Fe and Cu, leaving Al, Pb, Cd, Ca, Mg, Mn, Zn and Ni in solution. Ni is only completely retained in solution in case of the presence of mineral acid. A synopsis of the references to descriptions of separations effected by this reagent may be thus given:

Separation.	Experimenters.	Reference.
Co from Ni	V. Knorre & Ilinski	Berichte, 1885, 699.
Co from Fe and Al . .	" "	Berichte, 1885, 2728.
Fe and Cu from other met'ls	"	Berichte, 1887, 283.
" " "	"	Chem. Ind., 1887, No. 4.
Fe from Mn	"	Stahl u. Eisen, 1887, 170.
Fe from Be	Schleier	Chem. Ztg., 1892, No. 26.
Fe from Al	Breutel	Ber. œsterr. Ges. Chem. Ind. 1886, 129
Fe in raw materials . . .	Meinecke	Zts. angew Chem., 1888, pp. 3, 68, 219 and 252.
Fe from Mn. and others .	Kofahl	Inaug. Diss., Berlin, 1890.
Co from Ni	Fischer	Inaug. Diss., Berlin, 1888. Berghutten Ztg., 1888, 453.
" "	Krauss	Inaug. Diss., Erlangen, 1889. Zts. Anal. Chem., 1890, 241.

The presence of an excess of the reagent does not prevent the precipitation of Al by ammonia (Meinecke, Von Knorre and Ilinski).

The iron precipitate carries the most, if not all, the P_2O_5 present with it (Von Knorre and Ilinski, Meinecke, Kofahl).

A method for analyzing commercial nickel is given. It consists in dissolving in HNO_3, converting to sulphates by evaporation with H_2SO_4, diluting, filtering off SiO_2, etc., precipitating Cu by H_2S, oxidizing Fe, and then separating it by three precipitations with ammonia, and to the filtrate, adding Na_2SO_4 and excess of ammonia, and electrolyzing for Ni and Co. The use of Na_2SO_4 is recommended to avoid the formation of a difficultly soluble nickel ammonium sulphate, which sometimes gives trouble. The precipitated Ni and Co are weighed together, dissolved and separated by use of nitroso-β-naphthol. Krauss thought that the ignited precipitate thus obtained contained some carbon compound of Co, and was not pure Co_3O_4, unless ignited in a stream of oxygen. Von Knorre and Kofahl do not find this to be the case.

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Sodium Peroxide as a Reagent. Hempel (*Zts. f. Anor. Chem.*, iii., 193) recommends this substance as a reagent. At the fusion temperature it oxidizes Cr, Mn and W almost immediately to the form of acids, serves as a rapid means of decomposing titaniferous iron ore, and mixed with half its weight of soda will quickly oxidize mineral sulphides.

Phenolphthalein and Methyl Orange as Indicators. Breed (*J. Anal. and App. Chem.*, vii., 204, February meeting of Franklin Institute). Small amounts of CO_2 remain in solutions, rendering results with phenolphthalein as indicator incorrect, unless boiled for fully ten minutes. Methyl orange is preferable. In the discussion, attack of the glass was suggested by Haines as having an influence. The sensitiveness of phenolphthalein is five times as great as that methyl orange. Phenacetolin was found good, if the alcoholic solution was not filtered. Good methyl orange was difficult to obtain. Pemberton found variations in results might be due to the presence of Al_2O_3 in the standard alkali. Keiser found methyl orange to be more sensitive than phenolphthalein.

Separation of Strontia from Lime. Fresenius (*Fres. Zts. Anal. Chem.*, xxxii., 189). The following methods were examined:

Stromeyer's as Modified by H. Rose.—Dissolving Ca $(NO_3)_2$ from a mixture of the *dried* nitrates by a mixture of absolute alcohol and ether (equal volumes).

One part dry $Sr(NO_3)_2$ was found to be soluble in 83.044 parts ether-alcohol. One part dry $Ca(NO_3)_2$ was found to be soluble in 1.87 parts ether-alcohol. The method proved the best of those tried. Nevertheless, small amounts of Sr remained with the $Ca(NO_3)_2$, and small amounts of Ca with the $Sr(NO_3)_2$.

Rose's.—Treatment of the sulphates with $(NH_4)_2SO_4$ solution (1 : 4). The respective solubilities of the sulphates in $(NH_4)_2SO_4$ of this strength were: $CaSO_4$ 1 part in 287 parts—$SrSO_4$ 1 part in 16.949 parts. CaC_2O_4 was found to be not insoluble in $(NH_4)_2SO_4$. The separation was incomplete.

Fleischer's.—Five-minute boiling of mixed oxalates with K_2SO_4. The theory of this method is that CaC_2O_4 is unchanged, whereas SrC_2O_4 intercharges and affords K_2CO_4 and $SrSO_4$. Experiments showed that the CaC_2O_4 was not entirely unaffected, and, moreover, that the alteration of the Sr combination was not entirely complete, hence inexact results.

Sidersky's.—Simultaneous action of $(NH_4)_2SO_4$ and $(NH_4)_2C_2O_4$ in a neutral solution. The supposition was that $SrSO_4$ and CaC_2O_4 would precipitate simultaneously, and could afterward be separated by treatment with HCl. The separation was found to be unsatisfactory for various reasons: proportions of salts present, solubility of $SrSO_4$ in HCl, etc.

Colorimetric Determination of Iron in Well Waters. Gerhard (*Arch. d. Pharm.*, ccxxx., 705) recommends tannic acid for this purpose.

Titration of Iron by $SnCl_2$. Mahon (*Am. Chem. Jour.*, xv., 360). In solution of Fe_2Cl_6 containing $HgCl_2$, strongly acid with HCl, when nearly boiling, $SnCl_2$ reduces the iron first; any excess then reduces the $HgCl_2$, the Hg_2Cl_2 at first forming going into solution. If, how-

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ever, a small amount of $PtCl_4$ is present, the Hg_2Cl_2 will react with it and give a dark cloud of Hg and Pt. The author, therefore, proposes as indicator a solution containing 34 grammes $HgCl_2$ and 0.05 gramme Pt as chloride per litre. 15 c.c. of this indicator solution should be used for each titration, which should be conducted in a flask at or near the boiling temperature, that the strong HCl fumes may keep at a distance the oxygen of the air. The bulk of solution most convenient is about 200 c.c., in which 0.2 c.c. of $SnCl_2$ in excess will give a decided cloud with the indicator.

Iron and Alumina in Phosphates. Mariani and Tasselli (*Staz. Sper. Ag. Ital.*, xxiii., 31), criticize Glaser's method adversely, and propose the following method: Boil 1 to 5 grammes of the material with 15 c.c. conc. HCl for ten minutes, dilute, oxidize with a few crystals of $KClO_3$ and a few drops of HNO_3, boil out Cl and filter, bringing the filtrate and washings up to 150 c.c. To the solution when cold, add 2 c.c. glacial acetic acid and 0.5 gramme $(NH_4)_2HPO_4$, add ammonia little by little until a permanent precipitate forms, then 2 c.c. acetic acid. Shake well and let stand two hours. Filter and wash with 1 per cent. $(NH_4)_2HPO_4$ solution. Redissolve in a little HCl, and reprecipitate in the same manner as before. Ignite and weigh. Take half the weight of the precipitate as Fe_2O_3 and Al_2O_3.

Aluminum in Ferro Aluminum and Steel. Rozycki (*Mon. Sci.*, 1892, p. 815), ignites 0.2 to 2 grammes of the pulverized material in a platinum boat in a current of oxygen. In its alloys the Al is readily oxidized by this means. The mixed oxides are then heated in a stream of HCl gas which volatilizes the Fe, leaving Al_2O_3. By treatment with HF and igniting, pure Al_2O_3 remains.

Chromium in Steel. Clark (*J. S. C. I.*, xii., 340). Reference is made to:

a. Galbraith's process (*Chem. News*, xxxv., 151.) Dissolving in H_2SO_4, oxidizing with $K_2Mn_2O_8$, and titrating $H_2C_2O_4$ with ferrous salt.

b. Arnold and Hardie's (*Chem. News*, lvii., 153.) Precipitation as phosphate. This method is regarded as superior to the ammonia precipitation which tends to give high results as shown by Wilne (*Berichte*, xii., 2223), and Souchay (*Zts. Anal. Chem.*, v., 66).

c. Hogg's process (*J. S. C. I.*, x., 340.) Dissolving in acid, and making colorimetric comparison.

The methods proposed by the author are:

Phosphate Process.—Dissolve 2 to 5 grammes in HCl (gr. 1 : 1) and add ammonia till a slight permanent precipitate is obtained. Then add about 1 gramme Na_2HPO_4 in solution, and about twice that amount of $Na_2S_2O_3$ or Na_2SO_3 and boil for about ten minutes. Filter, wash, dry, and ignite at low heat. Crush, mix with eight times its weight of a mixture of 3 parts NaOH and 2 parts MgO. Heat for half an hour to complete oxidation, leach out with water, adding a little H_2O_2 if there is any appearance of manganate. Finally titrate with ferrous ammonium sulphate.

Sulphite Process.—Dissolve 2 to 5 grammes in HCl, add Na_2CO_3

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until a permanent precipitate forms; redissolve that in a drop or two of HCl, add Na_2SO_3 little by little, and boil out all SO_2. The precipitate of basic sulphite is filtered, washed, etc., and treated with MgO and NaOH as before described.

Chromium and Manganese in Steel. Schneider (*Œster. Zts. Bergh.*, 1892, 235), dissolves 2 grammes of steel in 100 c.c. H_2SO_4 (1 : 10), then boils with 5 c.c. HNO_3 until red fumes cease; 5 grammes PbO_2 are then added, and the boiling continued for fifteen minutes when the solution is filtered, rendered ammoniacal and boiled. In the clear solution Cr if present shows the yellow color of CrO_3 which is increased by acidifying with H_2SO_4. Without filtering, the Cr may be determined by addition of a known amount of $FeSO_4$ $(NH_4)_2SO_4$ solution, and titrating the excess with standard permanganate. By treating another portion of the sample in the same manner, omitting the treatment with ammonia, the oxidizing power of the H_2CrO_4 and $H_2Mn_2O_8$ is determined by use of the ferrous solution, and by making allowance for the oxidizing influence due to H_2CrO_4, that due to $H_2Mn_2O_8$ may be estimated, and consequently the proportion of Mn. In this latter operation the filtration should be through asbestos.

Estimating Manganese. Jean (*Bull. Soc. Chim.*, ix., 248), mentions Pattinson's method with approval (*vid.* QUARTERLY, xii., 336), also that of Volhard (*vid.* Blair, *Anal. of Iron*, etc., 2d. ed., p. 112), which he attributes to Guyard, and describes essentially the Ford-Williams method as if it were new.

Tests for Arsenic. Clark (*Proc. Lond. Chem. Soc.*, No. 124, p. 119), finds that "none of the methods which have been proposed for the generation of AsH_3 in an alkaline solution, detect arsenic acid." Reinsch's test as ordinarily conducted, gives uncertain results when the amount of As is small, and is not suited for quantitative estimations.

The author proposes to dissolve the As and Sb from the copper foil by cold digestion with dilute KOH and H_2O_2 solution, evaporation to small bulk, and distillation by Fischer's method ($FeCl_2$ and HCl). In the discussion, Dr. Dyer remarked on the fact that some forms of cast zinc hold back appreciable quantities of As in the Marsh apparatus; a phenomenon not noticed with granulated zinc. The presence of platinum black in the generating flask also tends to hold back some As.

Weyl's Method for Cu, Fe, Sb, and Zn Powder. Jean (*Bull. Soc. Chim.* [3], ix., 256.) The author's method of managing this process is described. It depends on the decolorizing effect of $SnCl_2$ on solutions of $CuCl_2$ or Fe_2Cl_6. The operation is performed in a flask, the contents of which are strongly acidified with HCl, and kept boiling during the titration that the flask may be filled with HCl vapors. The standard $SnCl_2$ solution is made by dissolving 4.5 to 5 grammes each in 500 c.c. of water containing HCl, which is standardized by a solution of crystallized $CuSO_4$ containing 0.1 gramme Cu in 10 c.c., strongly acidified with HCl for titration. When both Cu and Fe are present, the two are titrated together, then Cu is precipitated out with metalic Zn, and after oxidizing Fe by permanganate, the Fe_2Cl_6 is is titrated alone (Cu stand-

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ard × 0.88238 = Fe.) If $CuCl_2$ in known quantity is added to a solution of $SbCl_3$, titration gives Cu and Sb. On deducting the amount due to Cu, the remainder is due to Sb (Cu standard × 0.96214 = Sb.) Zinc powder (putty powder) may be dissolved in a measured quantity of $CuCl_2$ solution. On filtering off Cu, the Cu remaining in solution may be titrated after acidifying with HCl, etc. (Cu standard × 1.0236 = Zn).

Analysis of Impure Galenas. Jean (*Bull. Soc. Chem.*, ix., 253). Boil 25 to 30 grammes of the pulverized ore for an hour with conc. Na_2S solution to which flowers of sulphur have been added, replacing the water as it evaporates. Filter the solution which should contain all Sb and As. Acidify with HCl, dissolve the precipitate in aqua regia or in HCl and $KClO_3$, evaporate low; to one-fourth of the solution, add 10 c.c. $CuSO_4$ solution (containing 0.7 gramme Cu) and titrate by Weyl's method with $SnCl_2$ (to decolorization). From the apparent amount of Cu by titration deduct Cu added, and multiply the remainder by 0.66214 which gives weight of Sb. In another fourth of the solution add tartaric acid and ammonia, and determine As by Mg precipitation.

Dry the portion insoluble in Na_2S, pulverize with NH_4NO_3 and project the mixture in small portions at a time into a crucible heated to scarcely incipient red heat. Repeat this operation until the sulphides have all been oxidized, then pulverize and digest with dilute HCl. Then dilute largely (500 c.c.) and allow to stand some time for $PbCl_2$ and AgCl to separate. Wash by decantation.

To the acid solution add a little Na_2HPO_4 NH_4Cl and an excess of ammonia and $(NH_4)_2CO_3$, to precipitate the remaining $PbCl_2$, Mn, Mg and Ca. This precipitate, mixed with the first one, is dried, and fused with Na_2CO_3, a little borax and 1 to 2 grammes of starch. The argentiferous lead button is weighed, and then cupelled. In the ammoniacal filtrate from the Pb, etc., the Zn and Cu are titrated together with standard Na_2S solution. HCl is then added and heat applied to dissolve the ZnS. The CuS is filtered off, the solution boiled, then rendered ammoniacal and titrated again with standard Na_2S. This gives Zn, and the difference in the titration gives the Cu.

Electrolytic Separation of Copper and Antimony. Smith and Wallace (*J. Anal. and App. Chem.*, vii., 189). On converting the antimony to antimoniate, adding tartaric acid, and then rendering ammoniacal, copper only was precipitated by the current.

Electrolytic Separation of Mercury from Bismuth. Smith and Moyer (*J. Anal. and App. Chem.*, vii., 185). Perfect separation of these metals in HNO_3 solution was found to be impossible.

Determination of Vanadium. Hintz and Weber (*Fres. Zts. Anal. Chem.*, xxxii., 217), gives a review of different methods. Reference is made to the following papers:

Roscoe (Liebig's *Annalen*, suppl. vii., 70); Manasse (*ib.*, ccxl., 23); Rosenheim (*ib.*, ccli., 197); Krusss and Ohnmais (*ib.*, cclxiiii., 39); Ditte (*C. Rend.*, civ., 982); L'Hote (*ib.*, civ., 990); Carnot (*ib.*, civ., 1803 and 1850); Czudnowicz (*Pogg. Ann.*, cxx., 17); Rammelsberg (*Ber. Berl. Akad. Wiss.*, 1880); Gibbs (*Am. Chem. Jour.*, v., 370);

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Mohr (*Titrirmethode*, 5th ed., p. 314); Friedheim (*Ber.*, xxiii., 383); Kruss (*ib.*, xx., 1682).

To detect small amounts in minerals L'Hote recommends, to heat 4 parts of the pulverized substance intimately mixed with one part of C, to 250° C. in a current of dry Cl. V is volatilized as oxychloride which when conducted into water becomes V_2O_5. If it is present in small amounts the water remains colorless, but on evaporation to dryness and testing with NH_4HS, the characteristic purple coloration appears, with larger quantities the water is colored, and the V may be determined by evaporation with ammonia, or by reducing with Zn to V_2O_4 and titrating with standard $K_2Mn_2O_8$.

Titration with $K_2Mn_2O_8$.—Manasse finds this titration accurate in presence of WO_3 if both the $K_2Mn_2O_8$ solution and the solution titrated are dilute. The reduction is effected by SO_2, the excess of which is expelled by a current of CO_2.

Gibbs also reduces with SO_2 but in presence of H_2SO_4 and H_3PO_4. The reduction was found to be slow in presence of WO_3, which also masks the colors obtained unless dilute solutions are used. *Freidheim* finds this titration uncertain.

Reduction by conc. HCl.—Gibbs finds that on boiling with conc. HCl, V_2O_4 forms and Cl is evolved which may be titrated. *Rosenheim* asserts that this reduction is indefinite, some oxides intermediate between V_2O_5 and V_2O_4 being formed.

Separation by NH_4Cl.—Ditte notes that the solution must not be acid. After adding an excess of NH_4Cl and stirring, add 3 or 4 times the volume of alcohol, let stand, and filter and wash with alcohol. If salts insoluble in alcohol are present, treat twice or more with saturated NH_4Cl solution, containing undissolved salt, dissolve the residue in hot water, saturate with NH_4Cl and proceed as before directed. *Rosenheim* finds this separation unsatisfactory in presence of WO_3.

Precipitation by Mercurous Nitrate.—Rosenheim directs in case WO_3 is present, to add moderately dilute $H_{12}(NO_3)_2$ then NH_4OH to decided alkalinity and wash with dilute $Hg_2(NO_3)_2$ solution. Precipitate the filtrate with HCl or H_2S. The second precipitate also contains WO_3 and V_2O_5 and should be combined with the first, and the two dried and ignited. Add NH_4NO_3 and ignite again, before weighing combined oxides. The filtrate from the last precipitate may sometimes contain some V_2O_5, which may be determined by reducing and titrating with standard $K_2Mn_2O_8$. V_2O_5 is determined in another portion, and the WO_3 calculated by difference.

Freidheim precipitates with a concentrated neutral solution of $Hg_2(NO_3)_2$ and digests with excess of freshly precipitated HgO to neutralize the free acid. After cooling, heat with excess of conc. HCl for five minutes. V is reduced, $HgCl_2$ formed, and WO_3 dissolves. On adding a large amount of water WO_3 is precipitated. After filtering, the residue on the filter is dissolved in hot HCl (Sp. Gr. 1.12), allowed to stand twenty-four hours, when WO_3 separates, which is filtered off and washed with dilute HCl. In the filtrate the V is oxidized by one or two evaporations with HNO_3, finally ignited carefully and weighed as V_2O_5. The residue may contain WO_3 which is left behind by treatment with dilute H_2SO_4 and SO_2. On evaporating this solution with HNO_3

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pure V_2O_5 is obtained. Special attention to the purity of the reagents employed is indispensable.

Manasse find that alkaline earth vanadates are not completely decomposed by fusion with alkaline carbonates. Fusion with $KHSO_4$ is more efficient. He recommends separation of V_2O_5 as the lead salt. The precipitation should be effected in a warm solution, and the mixture well stirred, when it soon agglomerates. It should be at once filtered and washed with cold water; if allowed to stand long, the precipitate crumbles into a powder which will run through the filter. The precipitate is dissolved in HNO_3, evaporated with H_2SO_4 to fumes diluted, the $PbSO_4$ filtered off, and the V_2O_5 determined by $K_2M_2O_8$ titration.

Carnot separates as the barium salt. Neutralize, heat to boiling, add $BaCl_2$; let settle; cool quickly; filter; wash with cold water, dry, ignite and weigh $2BaO,V_2O_5$. The corresponding salts of the other alkaline earths do not precipitate except in concentrated solutions, containing excess of ammonia. This fact suggests a method for separating Ba from Si. The precipitate obtained by uranium salts in ammoniacal solutions or those weakly acids with acetic is $2UO_3,(NH_4)_2O,V_2O_5H_2O$ when dried, or $2UO_3V_2O_5$ when ignited. It can be used to separate V_2O_5 from alkaline earths Mn, Zn, Cu, etc., but not from P_2O_5, As_2O_5 MoO_3 or WO_3.

Mn salts will serve as a means of separating V_2O_5 from MoO_3, but not from the other acids above enumerated. The precipitation should be effected in a boiling solution containing NH_4Cl and a slight excess of ammonia.

Silicon in Iron and Steel. Parry and Morgan (*Ch. News*, lxvii., 149). A thorough mixing of the sample is of importance. Dissolve 4 grammes in 50 c.c. of aqua regia, evaporate to dryness and heat over a Bunsen, until the residue is black; cool—moisten with 60 c.c. HCl and evaporate until crusts begin to form, dissolve the crusts by a little HCl, add five times the volume of water, and filter through a paper previously washed with HCl, filter, wash four times with 10 per cent. HCl, and then with water. Ignite off the filter paper carefully at the lowest temperature possible and weigh SiO_2 and graphite; ignite strongly to burn off the graphite and weigh SiO_2. If much P is present the SiO_2 may be colored with Fe. Even if colorless, TiO_2 may be present. Fuse with 5 to 6 times its weight of $KHSO_4$, treat with water, and filter off pure SiO_2 or determine by loss (treatment with HF and H_2SO_4).

Good results (?) can be obtained simply by dissolving in 60 c.c., diluted H_2SO_4 (1:3). Evaporating to SO_3 fumes, diluting, filtering and washing, igniting the remaining SiO_2 and graphite as before described.

Phosphorus in Titaniferous Ores. Baskerville (*J. Anal. App. Chem.*, vii., 194). Dry 2 grammes at 100° for two hours, and then mix with about 20 grammes flux (10 parts Na_2CO_3 1 part KNO_3) and fuse in a platinum crucible. Keep at full fusion for five minutes, then cool, and leach out with water. Filter the solution (bulk about 300 c.c.) add 25 c.c. Fe_2Cl_6 solution (containing about 0.1 gramme Fe.). Acidify with HCl, boil, precipitate with ammonia, dissolve the washed precipitate in 40 c.c. HNO_3 (Gr. 1.43) and add 25 c.c. strong ammonia. Heat or cool to 85° C., add 30 c.c., molybdate solution, shake hard for one

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minute, let stand for five minutes more, filter and treat as per Handy's process (*vid.* QUARTERLY, xiii., 388), acidimetric titration.

Phosphorus in Iron and Steel. Parry and Morgan (*Ch. News*, lxvii., 161). Dissolve in aqua regia, evaporate to dryness, and heat over a Bunsen until the residue is black. Redissolve in HCl, evaporate low, take up with HCl and water, filter off SiO_2, etc. Evaporate repeatedly with HNO_3 to expel HCl, finally add enough HNO_3 to make the solution flow freely, and then 50 c.c. of molybdate solution (60 grammes $(NH_4)_2MoO_4$ per litre to which is added 50 c.c. ammonia and some NH_4NO_3). Partially neutralize with ammonia, let stand a short time, filter and wash with diluted HNO_3. Dry on a weighed filter, and calculate P. (1.66 per cent. of the precipitate). Low results were always obtained when SiO_2 was not separated previous to the precipitation of the P.

Phosphorus in Coal. Crobaugh (*J. Anal. App. Chem.*, vii., 223). Burn 5 grammes to ash in a platinum crucible, mix with 5 grammes Na_2CO_3 and 0.5 gramme KNO_3, fuse five minutes; cool, dissolve in 150 c.c. HNO_3 (Gr. 1.135) by the aid of heat filter into a shaking flask, and therefrom proceed as described (modifications of Emmertom's method, Handy, QUARTERLY, xiii., 388, Crobaugh, xiv., 165, or Pennsylvania Railroad method, *ib.*, xiv., 258).

Volumetric for Chlorides. Young (*Analyst*, xviii., 125), has investigated sources of error. Dilution was found to be one source, temperature, another; incidentally the solubility of Ag_2CrO_4 was determined and found to be 6 parts in 100,000 at 155° C and 18 parts in 100,000 at 100°. For correct results the solution of chloride should be evaporated low and the temperature kept down.

Separation and Estimation of Halogens. Friedheim and Meyer (*Zts. Anorg. Chem.*, i., 407). Introduce the solution into a retort and add KH_2AsO_4 and dilute H_2SO_4. I separates and may be distilled by the aid of steam into solution of KI, in which it is titrated by standard $Na_2S_2O_3$. The contents of the retort are cooled and conc. solution of $K_2Cr_2O_7$ added. Then on heating, Br is evolved, which is caught in a KI solution, and titration is again made with standard $Na_2S_2O_3$. The contents of the retort are acidified with HNO_3 and the Cl present determined gravimetrically by $AgNO_3$. Gooch and Browning (*Am. Jour. Sci.*, xlv., April, 1893), criticise this method as less rapid and convenient than their own (*vid. Am. Jour. Sci.*, xxxix., 188).

Iron by an Iodometric Method. Nihoul (*Rev. Univ. des Mines*, etc., xxi., No. 1), has devised a method for the determination of iron based on the reaction of Fe_2Cl_6 with KI or HI. The solution of ferric iron dissolved in HCl (which, if it contains ferrous iron, must be oxidized by $KClO_3$ and the Cl expelled by heat) is treated with KI or HI in a flask filled with CO_2 (a current of which gas is maintained throughout the distillation) in a flask connected with a Volhard flask containing KI. The reaction occurring is $Fe_2Cl_6 + 2KI = Fe_2Cl_4 + 2KCl + I_2$ or 1 part I = 0.4416 Fe. The I is driven over into the KI, the solution cooled

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in a current of CO_2 and then titrated with standard $Na_2S_2O_3$. The KI in the iron solution obstinately retains some I. This difficulty can be remedied by passing in a current of HCl gas, or by using HI instead of KI. A non-oxidizing atmosphere in the flask (CO_2) during distillation and cooling is absolutely essential.

Analysis of Commercial Nitrates. Devada (*Chem. Ztg.*, xvi., 1952), uses an alloy containing 45 per cent. Al, 50 per cent. Cu and 5 per cent. Zn, which, on solution in caustic alkali, in presence of a nitrate, affords NH_3. The Cu remains in a spongy form, which prevents bumping. The charge for the distilling-flask is 50 c.c. of water containing 0.5 gramme of the nitrate examined, 200 c.c. H_2O, 40 c.c. KOH solution (sp. gr. 1.3) 5 c.c. alcohol, and 2.5 grammes of pulverized alloy. A bulb filled with glass beads is mounted above the flask to prevent the mechanical carrying over of the alkaline solution, which is so liable to occur when H is evolved by alkali. Above the bead bulb is an empty bulb, and the neck above is connected with a condenser, the end of which dips below the surface of a solution of standard acid (20 c.c. half normal H_2SO_4). After charging, the mixture is heated gently for 20 or 30 minutes, and then distilled, when the distillate may be titrated back in the usual manner.

Stoklasa (*Zts. Angew. Chem.*, 193, 1861), reports on the examination of several different methods. He condemns utterly the "refraction" method and commends particularly Lunge's nitrometer method and that of Devada. He mentions in a foot-note the "silver" method of Wolfbauer, in which the nitrate is repeatedly evaporated with excess of HCl to convert all nitrate to chloride, which is finally dried, then dissolved and titrated with standard $AgNO_3$. On deducting the amount of $AgNO_3$ solution required in another portion of the original sample, a basis for calculation of the nitrate is obtained.

Determination of Nitrite. Deventer (*Berichte*, xxvi., 589, 932, 958), suggests the application of Schäffer's reaction (described in *Am. d' Chem.*, 1851), with ferro-cyanide and acetic acid: $2K_4FeCy_6 + 2HNO_2 + 2HC_2H_3O_2 = K_6Fe_2Cy_{12} + 2KC_2H_3O_2 + 2NO + 2H_2O$.

On measuring the NO, a basis for estimating the nitrite is obtained, giving results more satisfactory than by permanganate titration. The coloration due to formation of $K_6Fe_2Cy_{12}$ may be used as a qualitative test, and titration by $K_2Mn_2O_8$ affords a quantitative method for determining HNO_2 or dissolved oxygen by means of this reaction.

Deterioration of Crucibles. Dittmar and Prentice (*J. S. C. I.*, xii., 248), find that on fusing KOH or NaOH in silver or gold crucibles dehydration is practically complete in 10 minutes. The action of fusing KOH on gold is very slight in an atmosphere of H, and though much greater relatively in air is absolutely very trifling. Fusing NaOH had practically no action either in H or air. The action on Ag is perceptible, being naturally much greater in air. KOH is much more active in attacking Ag than NaOH.

Acids and Bases in Mineral and other Waters. Bothamley (*J. Lond. Chem. Soc.*, lxiii., 696), finds that in solutions containing CaO, MgO, CO_2 and SO_3 the combinations taking place are invariably $MgSO_4$ and $CaCO_3$.

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METALLURGY, BY JOSEPH STRUTHERS.

FUELS.—The American Coke Drawer. An illustrated description giving plan, elevation and sections.—*Amer. Manuf.*, May 12, 1893.

FUEL.—The manufacture of Coke.—One of a series of articles by John Fulton, E.M. Discusses coking in heaps and mounds and the Beehive Coke-Oven; giving illustrations of mounds and ovens. Includes analyses of coal and coke, and records of experimental tests as to time and its effect on the quality of the coke produced.—*Colliery Engineer*, April, 1893. Illustrated description of the Welch and Thomas ovens, showing various sections, etc.—*Colliery Engineer*, May, 1893.

BLAST.—Hot Blast Stoves. Continuation of discussion of Mr. Coffin's article on the Hugh Kennedy Hot-Blast Stove. Communication of Asa A. Weimer.—Advance sheets of the Montreal meeting of the American Institute of Mining Engineers, February, 1893.

BLAST-HEATING.—The application of Cowper stoves to chemical industries. By E. A. Cowper.—Description of stoves include illustrations of sections and valve for hot-blast, also the special shape brick used which is a hollow hexagonal with flanges at each corner.—*Journ. Soc. Chem. Ind.*, April 29, 1893.

IRON-ORES.—Production of Iron-Ore in the United States.—By John Birkinbine. Classifies the ores into red hematite, brown hematite, magnetite, and carbonate, and gives production by States. Total for 1892 shows:

	Long tons.
Red hematite,	11,646,619
Brown hematite,	2,485,101
Magnetite,	1,971,965
Carbonate,	192,981
	16,296,666

—*Amer. Manuf.*, May 26, 1892, from Census Reports.

IRON-ORES. Estimations of Arsenic and Phosphorus in Iron-Ores.—By Messrs. John and H. S. Pattinson. Description and discussion of method as applied to ores, iron, steel, etc., giving table of results. Paper read before the Newcastle Section of the Society of Chemical Industry.

BLAST-FURNACE PRACTICE. Utilization of Blast-Furnace Slag.—By Herr R. Zsigmondy. Short description of manufacture of bricks by moulding and by casting. Metallic plaster and slag cement.—From *Journ. Soc. Chem. Industries*, March 31, 1893; *Iron*, April 21, 1893.

CAST-IRON.—The manufacture of Charcoal iron from the Bog and Lake ores of Three Rivers District, Province of Quebec, Canada.—By P. H. Griffin, M.E. Description of ore-deposits and the works; giving the analyses of ores and products.—Advance sheets of the Montreal meeting of the American Institute of Mining Engineers, February, 1893.

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WROUGHT-IRON.—Treatment.—Illustrated description of the Leechburg improved squeezer for treating the puddle ball so that the rolls can easily take it. The illustrations are a front elevation and a vertical section.—*Amer. Manuf.*, April 14, 1893.

STEEL.—Production of Open-Hearth and Bessemer Steel in the United States and Great Britain for 1892:

United States.	Gross tons.
Open-hearth steel,	669,889
Bessemer steel,	4,168,435

Eighty open-hearth plants in operation at end of 1892.

Great Britain.	Gross tons.
Open-hearth steel,	1,418,830
Bessemer steel,	1,500,810

—*Amer. Manuf.*, April 28, 1893.

STEEL.—The Thomas Process in Belgium.—By M. Palgen and M. Tordeur. A translation from *Memoirs de l'Union des Ingeneures de Louraine*, 1892, and *Revue Universelle des Mines*, October, 1892. Description of process and analysis given of iron, refractory materials and slags. The plan at Saint Martin is shown by illustration.—*Amer. Manuf.*, May 26, 1893.

STEEL.—Charging Machine for Blooming Mill.—Illustrated and detailed description of machine in use at the Pacific Rolling Mill Company of San Francisco. Eight figures of drawing accompany this article. —*Iron Age*, April 27, 1893.

STEEL.—Mild Open-Hearth Steel for Castings.—By Messrs. A. B. Winder and J. Dixon Brunton, from a paper read before the Sheffield Technical School Metallurgical Society. Results of experiments made on a 16-cwt. charge in small furnaces, giving change of composition, of materials, and includes physical tests on product.—London *Iron*, April 21, 1893.

STEEL. Segregation in Steel.—By Walter E. Koch. From paper read before the Engineers' Society of Western Pennsylvania, Analyses quoted and dimensions given.—*Iron Age*, April 27, 1893.

ROASTING FURNACE. A New Form of Furnace for Roasting and Oxidizing Ores.—By W. P. Blake. Illustrated description of furnace; its main features being a series of concentric terraced floors, one above another, and the use of superheated air upon the charge without contact with fuel.—Advance sheets of the Montreal Meeting of the American Institute of Mining Engineers, February, 1893.

COPPER. The Bessemerizing of Copper-matte and the Production of Pig-copper.—By Charles Wade Stickney. Illustrated descriptive article on the present American practice. From "Mineral Industry for 1892." —*Eng. and Min. Journ.*, April 25 and May 6, 1893.

SILVER. Amalgamation.—Some points in silver milling by amalgamation. Letters published by C. H. Aaron, on the effect of chemicals

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in the amalgamation process, and general discussion as to applicability. —*Min. and Scient. Press*, February 25, 1893.

SILVER. Lixiviation.—Use of Producer-gas for drying and roasting ore at the Lixiviation Mill of the Holden Smelting and Milling Company, Aspen, Col. By Willard S. Morse. Description of drying, crushing, chloridizing, roasting, and lixiviating by hyposulphite and Russell's solution—gas-fuel used for drying and roasting. Taylor producer on coal of following composition: water, 1.7 to 2.8; volatile matter, 36.3 to 37.95; fixed carbon, 37.1 to 48.6; ash, 23.8 to 11.6; gas yielded by analysis, CO, 20 per cent., CO_2, 2.8 per cent.; composition of ore, Ag., oz. per ton, 27.91; Pb, 2.27; SiO_2, 21.64; $BaSO_4$, 20.92; CaO, 10.99; MgO, 4.24; Fe, 10.02; Zn, 2.85; S, 8.1. Ore, after roasting, averaged .2 per cent. of S as sulphide.—Advance sheets of Montreal Meeting of the American Institute of Mining Engineers, February, 1893; also, *Eng. and Min. Journ.*, February 20, 1893.

SILVER. Lixiviation.—A Review of the Russell Process. By L. D. Goodshall. A paper read before the Colorado Scientific Society, May 1, 1893.

SILVER. Lixiviation.—The Dewey Process for Refining Sulphide Precipitates. Description of the process now in use at the Marsac Mill, Park City, Utah.—*Eng. and Min. Journ.*, April 15, 1893.

GOLD. Variation in the Milling of Gold Ores. V. Ballarat, Victoria. By T. A. Rickard. Illustrated and descriptive article, giving details of mills and processes.—*Eng. and Min. Journ.*, April 29, and May 6, 1893.

GOLD. Lixiviation.—The Dissolution of Gold in a Solution of Potassium Cyanide. By R. C. Maclaurin.—*Proceedings Chem. Soc.*, May, 1893.

GOLD. Lixiviation. Description of the Bettel process for extraction of gold from the slimes; the principal factor is the use of a double cyanide of manganese and potassium ($K_6Mn_2Cy_{12}$), and the use of a filter-press. The material must be in an extremely fine state of division to make this process a success.—*Eng. and Min. Journ.*, April 15, 1893.

ALUMINIUM. Technical Importance of Aluminium and its Future Applications.—By Herr J. Klandy. Taken from *Journal of the Society of Chemical Industries*, March 31, 1893. Gives the effect of small and large quantities of aluminium on copper and steel, and a general discussion of the industry.—London *Iron*, April 28, 1893.

MANGANESE. The Greene-Wahl Process for Manufacturing Manganese and Alloys of Manganese Free from Carbon.—By F. Lynwood Garrison. Includes descriptions of the various processes which have been used. The Greene-Wahl process itself consisting in fusing a mixture of metallic aluminium with chemically purified oxide of manganese in a clay crucible lined with magnesite. Analysis of resultant metal showed manganese, 96.5; iron, 2; silicon, 1.5; aluminium, trace.—Advance sheets of Montreal Meeting of the American Institute of Mining Engineers, February, 1893.

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ALLOYS. Lecture by Prof. W. Chandler Roberts-Austen, C.B.—Description of various alloys used for art metal-work, including the history of the subject. Gives methods of casting and analyses of two important Japanese alloys.—*Engineering*, March 24, 1893, and March 31, 1893.

ALLOYS. Second Report to the Alloys Research Committee.—By Prof. W. C. Roberts-Austen. Paper read before the Institution of Mechanical Engineers. The sections deal with the history of the subject and experiments on porosity and the influence of impurities on copper, bismuth, lead, and tin.—*Engineering*, April 28, 1893; also London *Iron*, April 21, 28, and May 5, 1893.

METALS. Segregation in Metals.—By Mr. I. W. Hogg. Descriptive article on the varying composition of steel ingots, shown by analyses of different portions of ingot of steel, with discussion on same.—*Eng. and Min. Journ.*, April 29, 1893.

RECENT PAPERS ON THE GEOLOGY OF IRON ORES.

A number of papers have recently appeared which bear on the geology of iron-ores, and deserve connected mention. Over a year ago Prof. J. P. Kimball began, in the *American Journal of Science* (September, 1891, p. 231), a contribution on the "Genesis of Iron-Ores by Isomorphous and Pseudomorphous Replacement of Limestones," which was concluded in the *American Geologist* for December of the same year. Dr. Kimball presents strong arguments for the origin of many ore-bodies, especially the stratified, by the replacement of calcium carbonate with anhydrous, ferrous carbonate directly. He emphasizes the important, chemical reaction by which hydrous, ferrous carbonate, instead of anhydrous, falls whenever ferrous salts are precipitated by an alkaline carbonate, and from this argues that the bedded and lenticular masses of siderite have originated by molecular interchange. In the second part the conclusions are applied to many important ore-bodies, including the iron-ores in the Subcarboniferous limestone of eastern Kentucky; the Juragua ores of Cuba; ores at Leadville and Hot Springs, Colo.; the Clinton ores; the Carboniferous limestone ores; the Siluro-Cambrian limonites; Cornwall, Penn., magnetite; Lake Superior and Missouri specular ores, and many foreign examples. Many of the above applications are justifiable and right, but the Clinton ore has been since shown by C. H. Smyth, Jr., to whose paper we pass shortly, to be in many of its outcrops of quite different origin. He who would explain the now exhausted specular ore of Pilot Knob, Mo., as a replaced limestone, would also have a practically undemonstrable thesis. Nevertheless, where it can be applied the replacement of limestone furnishes us with a cause of whose chemical bearings we have some reasonable comprehension.

A somewhat different conception of origin is afforded by the paper of Professor Van Hise on the "Iron-Ores of the Marquette District of Michigan." (*Amer. Jour. Sci.*, Feb., 1892, p. 116). The author continues the researches begun by Prof. R. D. Irving and himself years before in the Penokie-Gogebic district. He shows that the ores in the

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Marquette region are in two formations, the Lower and the Upper Marquette. In the Lower Marquette four varieties of ore body are recognized: (1) deposits on the contact of quartzite conglomerate and the ore-bearing formation; (2) deposits resting upon soap rock, which grades into massive diorite; (3) deposits resting upon dikes of soap rock, which follow along or cut across the ore-bearing formation; (4) deposits interbedded in the jasper or chert. The iron is thought to have been derived from lean, cherty, carbonate beds and to have been precipitated, especially where the solutions came to rest above some impervious layer, such as a soapstone (altered diabase) dike, this being the commonest. In the Upper Marquette various other impervious rocks have furnished the footwall. In some instances it is a black slate, in others an intrusive basic eruptive, and in still others a surface volcanic. The ores occupy troughs on these or on the sides of synclinals, and exhibit all stages of change from unaltered carbonate through limonite to hematite. The author applies the same general explanation to the other hematite districts, but adds that he himself has given them as yet less personal attention.

H. V. Winchell, of the Minnesota Survey, has recently classified in a tabular statement all the possible theories for the formation of iron ores (*American Geologist*, November, 1892, p. 277). The scheme is a grouping of the various forms of origin set forth in Bulletin VI. of the Minnesota Geological Survey, 1891, p. 213, wherein a very complete review is given of theoretical views. Some eighteen different ones are cited, of which fourteen had been previously summed up by A. A. Julien (*Proc. Phila. Acad. Nat. Sci.*, 1882, p. 335). The main divisions of the table are mechanical and chemical. Under the first are the subheads: 1. Extra-terrestrial or cosmical; 2. Terrestrial. Under the second: 1. Changes in situ; 2. Removal by chemical action and subsequent deposition. Mr. Winchell seeks to classify a variety of ideas, which, in many cases have few natural affinities. It must be admitted that all the views cited have been at one time or another advanced, and as an historical summation the table has its value; but when speaking of "ores" one should not mean all iron minerals. Ores are only those in amounts to be of practical value. Meteoric irons are, for example, rare curiosities. Subterranean dikes or other igneous eruptions can hardly be considered of mechanical origin, though placed under 2 of this heading. The two subdivisions under Chemical would appear to mean pretty nearly the same thing. The table gives at a glance practically all that has been advanced explanatory of iron-ores, but many of the ideas are more ingenious than sound.

C. H. Smyth, Jr., brought out in the *American Journal* for July, 1892, p. 487, an abstract of his thesis on the Clinton iron-ore, which was presented for the Ph.D. degree to the faculty of the School of Mines in 1890. Much had been previously written about the Clinton ores, and the impression was widespread that they had generally resulted from the surface weathering of a highly ferruginous limestone, that became, at no great depth, too low grade to be of value. These views are undeniably correct for Alabama and other southern districts. Others had regarded the northern deposits as replacements of limestone, and one writer, Dr. Newberry, had likened them to the ōolitic limonites of the Swedish lakes. Dr. Smyth brings out the fact, not generally appreciated,

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that the ore at Clinton, N. Y., is a siliceous ore, and that it is öolitic and formed by small concentric layers of ferric oxide, interlaminated with thin shells of chalcedonic silica, and all deposited around a small grain of quartz as a nucleus. He then infers with justification that it is a shore deposit, and probably formed as hydrated peroxide, and became dehydrated to hematite in time.

H. V. Winchell has given us a very valuable and timely account of the enormous bodies of iron-ore, lately opened in the Mesabi Range, Minn. (The Mesabi Iron Range, *Twentieth Ann. Rep. Geol. Sur., Minn.*, 111–180, and republished in part in the *Trans. Amer. Inst. Min. Eng.*, Autumn, 1892.) The ores are soft and hard hematites and limonites which rest on the underlying, Pewabic quartzite of the Animikie group, and are associated with a cherty, jaspery quartzite, called by Winchell, taconyte. Over the ore in the geological section are greenish, siliceous slates, and cherts, but resting immediately on its accessible portions, is a heavy mantle of glacial drift, up to 75 feet thick, which has hindered the discoveries. Above the slates and cherts, comes the Animikie black slates and still later than these are the great masses of gabbro. Under the Pewabic quartzite are the unconformable green Keewatin schists and still lower the granite of the Giant's range.

Mr. Winchell pronounces the deposits true beds, and refers them to a form of origin by replacement of some pre-existing rock, presumably a very siliceous and ferruginous limestone, but he is free to admit that unchanged masses of it are yet to be found. To account for the presence and discover the source of these enormous amounts of iron-ore and silica are by no means simple problems, but the explanation suggested is at once an attractive and a reasonable one. The ores are largely bessemer, and are so soft that they can, in large part, be dug by steam shovels in open cuts. From all accounts they would seem to be, perhaps, the largest of the Lake Superior deposits.

Some very interesting papers have of late been written by Prof. J. H. L. Vogt, regarding the origin of bodies of titaniferous magnetites that are associated with rocks of the gabbro family, as excessively basic developments of igneous magmas. The greater number of his contributions are in Norwegian and Swedish, but a *résumé* in German is given in Vol. I., No. 1, p. 4, of the new *Zeitschrift für Praktische Geologie*, January, 1893, and in several subsequent numbers. To the same form of origin, bodies of nickeliferous pyrrhotite, in similar wall rocks, are referred. The papers are illustrated with many interesting cross-sections of Scandinavian mines and with references to ore-bodies elsewhere in the world. The idea is a good one and will doubtless be found quite widely applicable. The immense bodies of titaniferous ores now valueless, and receiving no practicable treatment, furnish a tempting field. In this connection, mention should be made of the recent investigations of Mr. Auguste J. Rossi—an account of which was published in the *Trans. Amer. Inst. Min. Eng.*, Feb., 1893, entitled, "Titaniferous Ores in the Blast-Furnace." Mr. Rossi cites many analyses and occurrences and brings out the curious fact that phosphorus and sulphur are extremely low, or lacking in these ores and that alumina rules high. Just in what way the elements are combined is a most interesting question, and it is quite possible that some hitherto unsuspected compounds may exist. J. F. K.

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BOOK REVIEWS.

THE MINERAL INDUSTRY: Its statistics, technology and trade in the United States and other countries from the earliest times to the end of 1892; being the annual statistical supplement to the *Engineering and Mining Journal*. Cloth binding, 628 pp. Published by the Scientific Publishing Co., of New York, 1893. Price, bound in cloth, $2 50; bound in paper, $2.

The subjects treated include: Acids, Aluminum, Antimony, Asbestos, Asphaltum, Bauxite, Borax, Brimstone, Bromine, Barytes, Chemicals and Chemical Fertilizers, Chromium, Coal, Cobalt, Copper, Corundum, Fluorspar, Gold and Silver, Graphite, Gypsum, Iron and Steel, Iron-Ores, Lead, Manganese, Mica, Natural Gas, Nickel, Petroleum, Phosphates, Platinum and Platinum Minerals, Precious Stones, Pyrites, Quicksilver, Soda (natural), Sulphur, Sulphuric Acid, Tin, Zinc, etc.

In treating each subject the author describes the occurrence and character of deposits in which the minerals are found; the characteristics of the mineral; methods of treatment; cost of mining; characteristics of metal or other products; costs; uses; statistics of production; imports and exports from the earliest times; consumption, total and *per capita;* review of markets; prices; foreign production, imports, exports and consumption.

Technical article by competent authorities give the recent progress in each department of mining, metallurgy and chemical industry, forming a valuable work of reference. The tables of itemized cost of production of many of the minerals and metals afford valuable information to all interested in the industry. J. S.

PHYSICAL MEASUREMENTS: A STUDENT'S MANUAL OF A LABORATORY COURSE IN PHYSICAL MEASUREMENTS. By Wallace Clement Sabine, A.M., Instructor in Harvard University. Boston: Ginn & Co. 1893. 126 pp., 8vo.

As the preface states, this book is primarily intended for use in certain courses at Harvard, and an outsider can imperfectly judge how well it attains its primary object. We can only speak in regard to its use in other laboratories, and there criticism must be divided between the manner of presentation and the course of experiments upon which it is based.

The subject-matter is clearly set forth and most of the explanations and discussions all that could be desired. The discussion of "significant figures" in a result is very good and quite complete. The most important point there omitted being, as to how many figures of a known factor, as 3.14159265 should be used in the special cases discussed.

The lack of an index and of formulæ in the form in which they are most commonly used, and of the usual tables will interfere with the use of the book as one of quick laboratory reference.

As to the experiments upon which the book is based some are very good but many are of so elementary a nature that the student may never

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see the regular and customary way of making the measurements. For example, he is taught in specific gravity by immersion to correct each weight for air displaced by weights, which is quite superfluous inasmuch as the desired quantity is the ratio of two weights; he must make all the corrections individually and immediately and apparently never uses the simple formula that contains once for all the corrections for displaced air, and the density of the water.

Experiments designed for showing a principle with the simplest means are very good, but should be supplemented by the complete and usual methods.

The experiments are all instructive and the course would be profitable if the Harvard methods of instruction were employed; though 180 hours of laboratory and 90 hours of home work seem a great deal of time to spend upon an elementary course.

The book is well printed and contains many good diagrams.

W. H.

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MEMORANDA FROM TREASURER'S REPORT.

Running expenses School of Mines, 5 years, 1887–1891,	$547,877.42
⅛ "general expense" account, heating, lighting, janitors, library, and general administration,	266,472.63
Interest, 5 years, on $1,000,000 real estate and plant,	250,000.00
Total for 5 years,	1,064,350.05
Receipts from fees during same period,	234,457.88
Deficit (including interest),	$829,892.17
Average expense per year,	212,870.01
Average receipts per year,	46,891.58
Average deficit per year (including interest),	165,978.43
Average deficit per year (omitting interest),	115,978.43
Average number of students during this period,	252
Average cost per student per year,	$841.00
Average receipts from each student, 20 per cent. of whom received free tuition,	186.00
Average deficit per student per year,	$655.00
Deficit per student for 4 years' course,	$2620.00

Each free student thus owes the college $3260 and each paying student $2460 on graduating from the school.

Total running expenses School of Mines since 1864,	$2,158,838.74
⅛ "general expenses" for same period,	473,084.64
Expended on buildings and equipments (gifts not included),	429,927.39
Estimated value real estate,	500,000,00
Total for 30 years,	3,561,850.77
Receipts during same period from fees,	898,308.15
Deficit (interest not included),	$2,663,542.62

Which is the debt owed to Columbia College by the Alumni of the School of Mines.

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LISTS

OF THE

ALUMNI OF COLUMBIA COLLEGE SCHOOL OF MINES

1893.

MEMBERS OF THE ALUMNI ASSOCIATION AND OTHER GRADUATES
DETECTING ERRORS IN THE SUCCEEDING LISTS
WILL PLEASE SEND CORRECTIONS TO

PROF. F. R. HUTTON,
SECRETARY,
COLUMBIA COLLEGE SCHOOL OF MINES,
OR TO
No. 12 WEST THIRTY-FIRST STREET,
NEW YORK CITY.

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(REVISED TO JUNE, 1893.)

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SAM'L W. ANDREWS, '90.	IV.	D. LeR. DRESSER, '89.

NOTE.—Correspondence concerning dues and other clerical details of the work of the Association may be conveniently addressed to MR. FRANCIS W. HOADLEY, Assistant to the Secretary and Treasurer, No. 12 West 31st St., New York City.

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LIST No. 1.

Contains the names of all Graduates and Members of the Alumni Association grouped by classes from the beginning. The details as to Residence and Professional Occupation are given in the second or alphabetical list for convenient reference.

(Revised to June, 1893.)

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CLASS LIST

OF

GRADUATES AND MEMBERS

OF THE

ASSOCIATION OF THE ALUMNI.

[NOTE.—Where the name is followed by a date, it denotes that the person is no longer living, and the date is the year of the death.]

1867.

Adams, J. M., 1892.
Bridgham, S. W.
Bronson, E. S.
Brown, F. G.
Church, J. A.
Cornwall, H. B.
Giddings, E. E.
Gracie, C. K., 1891.
Hale, A. W.
Harding, G. E.
Harmer, T. H.
Heath, F. M.
Tuttle, W. W.
Van Lennep, D.

1868.

Barnard, A. P.
Baxter, G. S.
Carson, J. P.
Chester, A. H.
Coursen, G. H.
Geer, G. J., Jr.
Hanna, G. B.
MacMartin, A., 1881.
Melliss, D. E.
Moffatt, E. S.
Parsons, G. H.
Pennington, J. P.
Pistor, W.
Platt, C. S.
Robertson, K.
Shack, A. P.
Schermerhorn, F. A.
Smith, L.
Smith, W. A.
Stalknecht, F.
Van Arsdale, W. H.
Wheeler, M. D., 1889.

1869.

Blossom, T. M., 1876.
Bruckman, F.
Campbell, A. C.
Delafield, A. F.
Hooker, W. A.
Huntington, C.
Irving, R. D., 1888.
Jenney, W. P.
Munroe, H. S.
Nettre, L. R.
Newton, H., 1877.
Potter, W. B.
Randolph, J. C. F.

1870.

Haight, O., 1891.
Ingersoll, W. H.
Knapp, J. A.
Lilienthal, J. L.
Lindsley, S.
Parrot, E. M.
Terhune, R. H.
Van Wagenen, T. F.
Waller, E.

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1871.

Fales, W. E. S.
Goldschmidt, S. A.
Gordon, J.
Ricketts, P. de P.
Riggs, G. W.
Roberts, G. S.
Robertson, R. S., Jr.

1872.

Austen, P. T.
Jenney, F., 1876.
McDowell, F. H.
Sloane, T. O'C.
Wendt, A. F.

1873.

Canfield, F. A.
Colton, C. A.
Mott, H. A.
Webb, H. W.
Williams, J. T.

1874.

Allen, C. S.
Benedict, W. de L.
Cameron, J. G. M., 1892.
Ledoux, A. R.
Lillie, S. M.
Murray, G.
Olcott, E. E.
Rees, B. F.
Rhodes, F. B. F.
Williams, F. H.

1875.

Ihlseng, M. C.
Iles, M. W.
Jackson, C. E.
Joy, D. A., 1888.
Lamson, R., 1876.
Leavens, H. W.
Macy, A., 1891.
Noyes, W. S.
Pfister, P. C.
Putnam, B. T., 1886.
Rees, J. K.
Rolker, C. M.
Russell, S. H., 1892.
Stewart, H.
Thompson, M. S.
Tucker, J. H.
Vanderpoel, F.
Wells, J. S. C.
Wetmore, E. A.
Wright, A. A.

1876.

Austin, T. S.
Bruen, F. E., 1884.
Cornwall, G. R.
Craven, F. C., 1890.
Foote, H. C., 1888.
Garrison, E. H.
Gratacap, L. P.
Hall, R. W.
Hamilton, S., Jr.
Holbrook, F. N.
Hoyt, W. L.
Hunt, F. F.
Hutton, F. R.
King, C.
Lord, N. W.
Love, E. G.
Maghee, J. H.
Morewood, H. F.
O'Grady, J. W., 1890.
Randolph, J. F.
Ross, W. C.
Schneider, A. F.
Tilden, G. C.
Van Blarcom, E. C.
Walbridge, A. C., 1892.
Wardlaw, J. R.

1877.

Barros, L. de S.
Barus, C.
Beard, J. T.
Behr, E.
Buckley, C. R.
Cady, L. B.
Canfield, A. C.
Cauldwell, J. B.
Clark, H. G., 1881.
Colby, C. E.
Constant, C. L.
Cornell, G. B.

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Floyd, F. W.
Helleberg, F. S., 1883.
Hildreth, W. E.
Ihlseng, A. O.
Jordao, J. N. P.
Kelly, W.
Mackintosh, J. B., 1891.
Martin, E. W.
Murphy, J. G.
Nichols, R.
Norris, D. H.
Priest, J. R., 1880.
Radford, W. H.
Reed, S. A.
Rogers, C. L.
Sage, E. E.
Smeaton, W. H.
Smythe, R. M.
Thacher, A.
Van Boskerck, R. W.
Waterbury, C. R.

1878.

Adams, W. J.
Benjamin, M.
Blydenburgh, C. E.
Downing, O. P.
Drummond, I. W.
Eliot, W. G.
Fernekes, A., 1884.
Haas, H. L.
Hasegewa, Y.
Hodges, H. A., 1883.
Holden, E. H.
Hollis, W.
Johnson, E. M.
Johnson, G. H.
Karr, C. P.
Booraem, R. E.
Brinkerhoff, G. C.
Butler, W. P.
Lawrence, B. B.
Lyman, F.
Martin, N.
McCulloh, E. A.
Morewood, G. B.
Morris, G. W.
Munsell, C. E.
Murphy, H. N.
Nambu, K.
Newberry, S. B.
Cushman, A. R.
Davis, J. W.
Devereux, W. B.
Noyes, J. A.
Olmstead, O. F., 1881.
Owen, F. N.
Palmer, C. E.
Parker, R. A.
Pazos, V. F.
Perry, N. W.
Strieby, W.
Willis, B.

1879.

Bolton, R.
Britton, N. L.
Cloud, L. G.
Cornwall, H. C.
Deluze, L. P.
Eastwick, G. S.
Haffen, L. F.
Harker, C. S.
Hathaway, N.
Hollerith, H.
Hollick, C. A.
Johnson, I. B.
Johnston, R. A.
Koch, E. C.
Leggett, T. H.
Ludlow, E.
Marsh, C. W.
Mathis, T. S.
Mayer, R. E.
Merwin, H. J.
Milliken, G. F.
Munroe, O. M.
Neftel, K.
Nesmith, J.
Noble, C. M.
Reed, W. B. S.
Rhodes, R. D.
Rutherford, F. M.
Sheldon, G. H., 1889.
Starr, H. F.
Stewart, F. B., 1879.
Stone, G. C.
Suydam, J. R., Jr.
Williams, G. W.

1880.

Beebe, A. L.
Benjamin, F. P.
Browning, F. D., 1885.
Browning, J. H. B.
Brugman, W. F.
Butler, N.
Churchill, A. D.
Clark, E. P.
Elliott, W.
Engel, L. G.
Francke, R. O.
Garlichs, H.
Greene, W. U.
Greenleaf, J. L.
Hallock, A. P.
Hendricks, H. H.
Hooper, L. M.
Hopke, T. M.

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Hudson, E. H.
Klepetko, F.
Kunhardt, W. B.
Mattison, J. G.
Meissner, C. A.
Merritt, J. H.
Navarro, J. A.
Parker, A. McC.
Parks, J. R.
Robinson, H. A.
Ruttman, F.
Singer, G.
Singer, G. H.
Smalley, W. B., 1886.
Smith, M.
Tonnelé, T.
Torrey, C. H.
Walker, J., Jr.
Wheeler, H. A.

1881.

Andresen, C. A.
Aschman, F. T.
Bleecker, C. P.
Braschi, V. M.
Bush, E. R.
Chazal, P. E.
Colby, A. L.
Curtis, C. G.
Douglas, E. M.
Dunham, E. K.
Elliott, A. H.
Furman, H. V. F.
Griswold, W. T.
Hemmer, F. A.
Judd, C. B.
Leary, D. J.
LeBoutillier, C.
Ledoux, A. D.
Little, W. P.
Meserole, W. M.
Neymann, P.
O'Connor, M. J.
O'Connor, T. D.
Pitkin, L.
Raymer, G. S.
Richmond, W. T.
Roberts, A. C.
Sawyer, C. P.
Share, W. W.
Starr, C. D.
Stearns, T. B.
Swain, A. E.
Tuttle, E. G.
Van Sinderen, A. H.
Vulté, H. T.
Wiechmann, F. G.
Williams, W. F.
Wilson, H. M.

1882.

Calman, A.
Conant, T. P., 1891.
Cooper, W. H.
Crocker, F. B.
Dougherty, O. V., 1889.
Downes, S. B.
Downs, W. F.
Emrich, A. F.
Falk, D. B.
Feuchtwanger, H.
Fitch, C. L.
Going, C. B.
Hill, W.
Illig, W. C.
Joüet, C. H.
Mesa, A. E.
Moses, A. J.
Oothout, E. A.
Page, W. S.
Parsons, W. B.
Payne, C. Q.
Porter, J. B.
Powers, C. V. V.
Sands, F.
Shumway, W. A., 1892.
Staunton, W. F.
Stockwell, N. S., 1888.
Toucey, D. B.
Traphagen, F. W.
Vondy, R. H.
Wainwright, J. H.
Wanier, A. G.
Ward, N. R.
White, W. S.
Wilson, W. A.
Wittmack, C. A.
Young, E. L.

1883.

Abeel, G. H.
Adams, R.
Ayestas, A.
Balch, S. W.
Banks, J. H.
Bardwell, A. F.
Brereton, T. J.
Brewster, H. D.
Bullman, C.
Carrère, J. M.
Channing, J. P.
Endicott, G., 1889.
Ferrer, C. F.
Ferris, J. C.
Fiallos, E. C.
Haasis, D. F.
Humbert, W. S.
Lilliendahl, A. W.

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MacTeague, J. J.
McKenna, C. F.
Oxnard, J. G.
Painter, J. G.
Paraga, C.F.
Peele, R., Jr.
Powell, F.
Randolph, E.
Renault, G.
Rich, J. M.
Richardson, J. C.
Ridsdale, T. W.
Suter, G. A.
Tibbals, G. A.
Tower, A. E.
Walker, A. L.
Weed, W. H.

1884.

Adams, W. C.
Alden, H. C.
Baldwin, W. M.
Barnard, E. C.
Barratt, E. G.
Bodelsen, O.
Brinley, J. R.
Bryce, W.
Buckingham, F. E.
Burritt, W. W.
Corcoran, J. T.
Del Calvo, F.
Duncan, W. P., 1889.
Dusenberry, W. T.
Easton, L. C.
Fahys, G. E.
Fitch, J. H.
Fitzgerald, G. E.
Fowler, S. S.
Glover, C. G., 1888.
Gosling, E. B.
Griffin, S. P.
Gross, L. N.
Horn, J. T.
Kemp, J. F.
Lamb, A. J.
Luttgen, E.
McGenniss, J.W., Jr., 1890.
McKim, R. A.
McLoughlin, C. S.
Miller, C. W.
Moeller, W., 1887.
Moran, D. E.
Morgan, W. F.
Mulford, R.
Napier, A. H.
Newberry, W. E.
Newbrough, W.
Nolan, F.
Northrop, J. I., 1891.
Nye, A. C.
Painter, C. A.
Pearis, C. F.
Pellew, C. E.
Post, A. S.
Powers, L. J.
Proctor, W. R.
Reckhardt, D. W.
Roeser, F.
Rood, R. G.
Rowland, C. B.
Rupp, P., Jr.
Schoney, E., 1888.
Sherman, F. D.
Slack, C. G.
Smedberg, H. A.
Snook, T. E.
Speyers, C. L.
Tibbals, S. G.
Value, B. R.
Walbridge, F. K.
Wood, G. E.

1885.

Amy, E. J. H.
Barkley, H. F.
Bemis, F. P.
Brennan, A. J.
Bush, W. F.
Cary, G.
Clark, F. S.
Cozzens, H.
Crowell, C. B.
Detwiller, C. H.
Doolittle, C. H.
Dwight, A. S.
Eddie, E. C.
Engelhardt, E. N.
Graff, C. E.
Hart, B.
Hawkes, E. McD.
Hildreth, R. W.
Hollis, H. L.
Huntington, F. W.
Ingram, E. L.
Johnson, A. G.
Lacombe, C. F.
Lee, G. B.
Mannheim, P. A. L.
Marié, L.
Meyer, H. H. B.
Merrill, F. J. H.
Miller, C. L.
Moldehnke, R. G. G.
Noble, L. S.
Norris, R. V. A.
Page, G. S.
Pierce, H. N.
Polledo, Y. Y.
Sanders, W. E.
Shope, H. B.
Starek, E.
Struthers, J.
Thomas, F. M.
Titus, W. H.
Van Cortlandt, E. N.
Watson, F. M.
Whitman, E. P.
Wiltsie, E. A.
Woolson, I. H.

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1886.

Agramonte, E., Jr.
Agramonte, J. C.
Bell, H. M., Jr.
Berry, W. G.
Casey, E. P.
Conant, H. D.
Edwards, R. M.
Frankfield, E.
Good, G. McC. H.
Horne, W. D.
Howe, E.
Janeway, J. H.
Jenks, A. W.
Kissam, H. S.
Lederle, E. J.
Lee, H. C.
Newhouse, E. L.
Norton, L. H.
Ormsbee, J. J.
Osterheld, T. W.
Peck, S. B.
Porter, H. H., Jr.
Ryon, A. M.
Spooner, A. N.
Stodder, R. H., 1887.
Stuart, W. H.
Thompson, H. C.
Trowbridge, S. B. P.
Van Brunt, A. H.
Von Nardroff, E. R.
Wallace, W. J.
Wheatley, J. Y.
Wilson, C. E.

1887.

Aldridge, W. H.
Appleby, W. R.
Bellinger, H. P.
Bien, J. R.
Burns, A. L.
Burns, E. Z.
Butler, W. C.
Church, E. D.
Cole, H. M.
Congdon, E. A.
Cox, J. S., Jr.
Darwin, H. G.
Davis, C. H.
Donnell, H. E.
Ferguson, W. C. A.
Gage, S. E.
Goldsmith, B. B.
Gudeman, E.
Heinsheimer, A. M.
Huntting, H. O.
Jacobs, D. M.
Jacobs, S. J.
Jeup, B. J. T.
Lahey, J.
Lahey, R.
Luquer, L. McI.
Lusk, G.
MacKaye, H. S.
Mannheim, H. C.
Marsh, J. R.
Middleton, J.
Moeller, R.
Muller, G.
Nichols, H. P.
Primelles, J. A.
Restrepo, C.
Rice, G. S.
Rowland, G.
Rutherford, L. H.
Schieffelin, W. J.
Seligman, J. G.
Simonds, F. M.
Slade, R. E.
Stanton, F. McM.
Staunton, J. A., Jr.
Stevens, A.
Tower, F. W.
Trask, G. F. D.
Tyler, W. L.
Warner, J. L.
Wels, P. O.
Wertheimer, L.

1888.

Allen, R. L.
Appleby, J. S.
Baker, G. L.
Bartlett, F. R.
Bechstein, C. A.
Beckwith, C. E.
Berry, G.
Colt, S. B.
Comstock, C. N.
Dodge, F. D.
Dodsworth, W. A.
Dow, A. W.
Fisher, W.
Frank, J. W.
Gardner, W. D.
Hebert, O. B.
Hopke, F. E., 1890.
Jones, W. D.
Koen, J. J.
Lenox, L. R.
Lipps, H., Jr.
McIlvaine, A. R.
Maclay, J.
Morgan, L.
Miller, R. P.
Munoz del Monte, A. C.
Parker, O. B., 1891.
Parsons, H.
Percival, G. S., 1892.
Perkins, T. S.
Schumann, C. H.
Shriver, H. T.
Smith, F. P.
Smyth, C. H., Jr.
Stoughton, A. A.
Taylor, J. B.
Tucker, A.
Van Dyck, E.
Van Volkenburgh, E.
Volckening, G. J.
Wampold, L.
Ward, D. W.

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1889.

Atha, H. G.
Berry, G.
Brown, R. G.
Cramer, S. W.
Cromwell, J. W.
Denton, F. W.
Dresser, D. LeR.
Eastwick, E. P.
Eilers, K. E.
Escobar, F.
Fearn, P. LeR.
Fowler, A. C.
Freedman, W. H.
Gifford, S. D.
Griffith, V. C.
Griggs, W. E.
Guiterman, E. W.
Harrington, T. H.
Harris, E.
Heinze, F. A.
Holt, M. B.
Ives, A. S.
Jopling, R. F.
Luquer, T. T. P.
Mahony, A. S.
Mapes, C. H.
Mason, C. S., 1889.
Massa, C. G.
Matthews, C. T.
Monell, J. T.
Mosley, R. K.
Oseransky, I. H.
Piez, C.
Post, A. Van Z.
Preston, W. E.
Provost, A. J., Jr.
Provot, G.
Raymond, R. M.
Raynor, R.
Rogers, O. L.
Schroeder, J. L.
Skidmore, S. T.
Small, F. M.
Smith, A.
Smith, F. M.
Stoughton, C. W.
Waters, G. S.
Wedekind, E. H.
Weekes, E. F., 1893.
Weeks, W. H.
Whitlock, H. P.

1890.

Andrews, S. W.
Beckwith, G. A.
Behlen, H.
Betts, R. T.
Black, A. L.
Blake, E. M.
Book, D. D.
Bradley, S. R.
Buckland, W. A.
Cairns, F. I.
Carson, J.
Clark, D. L.
Clayton, W. R.
Colton, F. G.
Connell, H. R.
Coykendall, T. C.
Davis, W. M.
Deghneê, J. A.
Douglas, J. S.
Ferguson, G. A.
Fisher, L. W.
Foyé, A. E.
Gudewill, C. E.
Gould, E. C.
Hart, C. H.
Hewlett, J. M.
Hicks, G. J., 1891.
Hinman, B. C.
Hooper, F. C.
Hoyt, J. S.
Hurlburt, E. D., Jr.
Jarmulowsky, M.
Jones, T. J.
Kohn, R. D.
Korn, L.
Levy, A. L.
Lichtenstein, E. G.
Lowndes, W. S.
McKleroy, W. H.
Mann, H. B.
Massa, L. F.
Meikleham, T. M. R.
Montenegro, M. R.
Parker, H. C.
Portuondo, J.
Post, W. S.
St. John, T. M.
Steers, J. R.
Thorne, W. L.
Wainright, R. T.
Warren, C. P.
Welch, A. McM.
Welsh, H. F.

1891.

Anderson, Geo.
Bliss, C. P.
Blossom, F.
Boecklin, W.
Boyd, R. C.
Brosnan, F. X.
Cristy, E. B.
Eberhardt, Wm. G.
Goodwin, E.
Hawley, J. F.
Holter, N. B.
Hornbostel, H. F.
Keeler, F. S.
Kinsey, F. W.
Langthorn, J. S.

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Leary, Geo.
Lilliendahl, F. A.
Livingston, A. R.
Mahl, J. T.
Miller, E. H.
Mora, M. L.
Raymond, A.
Skinner, E.
Strout, W. A.
Thomas, F. C.
Totten, G. O., Jr.
Tucker, S. A.
Tuska, G. R.
Warren, L.
Watson, R. B.
Wiener, Wm.

1892.

Ansbacher, L. A.
Anthon, A.
Bergen, C. H.
Bolles, R.
Burden, H., 2d.
Casamajor, G. H.
Clark, Edmund.
Clarke, W. C.
Dolan, C. F.
Dufourcq, E. L.
Durham, E. B.
Dutcher, B. H.
Fenner, C. N.
Friedman, S.
Gillette, H. P.
Granger, A. D.
Hay, A.
Herckenrath, W. A.
Jackson, O.
Kletchka, J. J.
Livingston, G.
Longacre, L. B.
Lord, F. R.
McIlhiney, P. C.
McKinlay, J. B.
Meisel, F. C. A.
Merz, E.
Pierce, F. E.
Reckhart, G. F.
Ries, H.
Rosenthal, A.
Savage, S. M.
Southard, G. C.
Temple, S. J.
Towart, J.
VanIngen, D. A.
Werner, H. C.
White, R. D.
Windecker, C. N.
Windolph, A. P.

1893.

Agramonte, I. E.
Aldrich, C. H.
Ayres, W. C.
Behrman, G. W.
Bossange, E. R.
Brooks, W. F.
Canfield, M. C.
Clark, G. H.
Covell, W. S.
Foster, R. G.
Gregory, L. E.
Hankinson, A. W.
Harte, C. R.
Haskell, H. G.
Hoyt, R.
Hyde, F. S.
Jones, J. E.
Kurtz, E. L.
Langmuir, A. C.
Liebmann, A.
McKee, S. H.
Macy, V. E.
Malukoff, A. J.
Matthew, W. D.
Newton, T. M.
Oakes, J. C.
Pederson, F. M.
Pomeroy, W. A.
Post, R. B.
Prince, A. D.
Provot, F. A.
Reynolds, M. T.
Robinson, F. G.
Schroter, G. A.
Smith, H. A.
Thompson, S. C.
Tilghman, H. A.
Tuttle, W.

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LIST No. 2.

This list embraces the members of the Alumni Association of the School of Mines under the Constitution of that body. It is urged that all graduates of the School should list themselves under this group. Names not found here are grouped in List No. 3, which includes graduates who are not also members. All graduates are requested to try to make and keep this list correct and accurate.

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MEMBERS

OF THE

ALUMNI ASSOCIATION OF THE SCHOOL OF MINES.

A.

ABEEL, GEORGE HOWARD, E.M., ... 1883.
Box 621, Hurley, Iron Co., Wis.
1883–1884, Chemist Iron Cliffs Co., Negaunee, Mich. 1885–1888, Assistant Manager Iron Cliffs Co. 1888–1889, Manager Ironton Iron Mining Co., and Agent Pilgrim Mining Co. 1889, Supervisor Bessemer Township, Gogebic Co., Mich. 1888 to date General Manager of Montreal River Iron Mining Co., Hurley, Wis., and 1889–92 Agent Ruby Iron Mining Co., Bessemer, Mich. General Manager Section 33 Iron Mining Co. Vice-president 1st National Bank, Hurley, Wis. Vice-president Wisconsin Supply Co., Hurley, Wis.

ADAMS, RANDOLPH, E.M., ... 1883.
Broken Hill, N. S. Wales, Australia.
1884–87, Assistant Superintendent and Superintendent of the Silver King Mine, Silver King, Arizona. 1887–91, engaged in Australia as Mining Superintendent and Mining Expert, and now Manager of the Central Broken Hill Mine, Broken Hill, N. S. Wales, Australia.

ADAMS, WILLIAM CRITTENDEN, C.E., ... 1884.
Address unknown.

AGRAMONTE, EMILIO, C.E., ... 1886.
118 E. Seventeenth Street, New York City.

ALDRIDGE, WALTER HULL, E.M., ... 1887.
United Smelting and Refining Co., East Helena, Montana.
Beginning July, 1887, Assayer at Colorado Smelting Co., Pueblo. At different times, Chemist of Colorado Smelting Co., Pueblo. August, 1890–91, Assistant Superintendent and Metallurgist of Colorado Smelting Co., Pueblo. Assistant Manager United Smelting and Refining Co. 1893, Manager as above.

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ALLEN, CHAS. SUMNER, PH.B., M.D., ... 1874.
Practicing Physician.

ALLEN, ROBERT LAWRENCE, A.M., E.M., . . . 1888.
102 Cambridge Place, Brooklyn, N. Y.

AMY, ERNEST JULIUS HYACINTHE, A.B., E.M., . . 1885.
Durango, Colo.

1885–1886, Chemist and Assayer at works of the San Juan and N. Y. M. and S. Co., at Durango, Colo., with the exception of three months' professional visit to Old Mexico. 1886–1887, Assistant Manager of the San Juan and N. Y. M. and S. Co., at Durango, Colo. 1887–1888, Manager of the Hazelton Mountain Mining Co., at Silverton, Colo. 1888 to April 1, 1890, Assistant Manager of Works of the San Juan Smelting and Mining Co., at Durango, Colo. (the S. J. S. and M. Co. being formed by the consolidation of the S. J. and N. Y. M. and S. Co., of Durango and the Hazelton Mt. Mfg. Co., of Silverton, Colo.). Since April 1, 1890, General Manager of the San Juan Smelting and Mining Co., at Durango, Colo.

ANDREWS, SAMUEL WAKEMAN, JR., PH.B., . . . 1890.
35 W. Forty-second Street, New York City.

ANSBACHER, LOUIS ADOLPH, PH.B., ... 1892.
A. B. Ansbacher & Co., 4 Murray St, New York City.

ANTHON, ARCHIBALD (Associate), ... 1892.
21 Church St., Salem, Mass.

APPLEBY, W. R., A.B. (Associate), ... 1887.
Professor of Mining and Metallurgy, University of Minnesota, and 911 Fifth St., S. E., Minneapolis, Minn.; also 29 Bentley Avenue, Jersey City, N. J.

ATHA, HENRY GURNEY, PH.B., ... 1889.
756 High Street, Newark, N. J.

AUSTEN, PETER TOWNSEND, PH.B., PH.D., . . . 1872.
331 Produce Exchange, N. Y. City, and New Brunswick, N. J.

1877–1880, Assistant Professor of Analytical Chemistry, Rutgers College. 1880–1889, Professor of General and Applied Chemistry, Rutgers College. 1891–1893, Analytical Chemist. 1893, Professor of Chemistry, Polyt. Institute, Brooklyn, N. Y.

AUSTIN, THOMAS SEPTIMUS, E.M., ... 1876.
Monterey, Mexico.

1877–1878, in Cuba as Chemist. 1879–1880, Assayer Germania Smelting Co. 1880–1890, Superintendent Rio Grande Smelting Co., Socorro, N. M.

B.

BAKER, GEORGE LEWIS, PH.B., ... 1888.
Address unknown.

BALCH, SAMUEL WEED, E.M., ... 1883.
Box 333, Yonkers, N. Y., and 757 Equitable Building, N. Y. City.

1883–1884, Otis Elevator Co. 1884–1886, Mowing Machines. 1886–1889, Garvin Machine Co., Tools and Special Machinery. 1889 to date, General consulting practice as Mechanical Expert and Patent Attorney. Specialty, Difficult Mechanical Problems.

BALDWIN, WILLIAM M., PH.B. (Life Member), . . 1884.
55 Beekman St., N. Y. City, and Garden City, Queens Co., N. Y.

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Since 1885, Chemist for the New York Dye Wood Extract and Chemical Co. Since 1888, Vice-President of the above corporation, and at present having charge of their manufacturing department.

BANKS, JOHN HENRY, E.M., ... 1883.
104 John Street, New York City.
Chemist, Assistant in Assaying and Analytical Chemist. Specialty, Metallurgical Products.

BARDWELL, ALONZO FRICK, E.M, ... 1883.
Box 773, Aspen, Col.

BARNARD, EDWARD CHESTER, E.M., ... 1884.
U. S. Geological Survey, Washington, D. C.
Assistant Topographer and at present Topographer in the United States Geological Survey, 1884–1891. Have been engaged in mapping in Virginia, West Virginia, and the mountains of East Kentucky. 1893, Mapping Northern New York.

BARRATT, EDGAR GRANT, C.E., ... 1884.
1022 The Rookery, Chicago, Ill.
1884–1888, Engineer for The Exhaust Ventilator Co. 1888 to date, President and Proprietor of The Exhaust Ventilator Co. 1891 to date, President and General Manager of the Variety Manufacturing Co. Fill the above positions at present and am consulting Ventilating and Heating Engineer.

BARTLETT, FRANK ROOT, C.E., ... 1888.
Care R. & D. R.R., P. O. Box 14, Greensboro, N. C.
1888 to date, Assistant Engineer Maintenance of Way on Atlanta and Charlotte Division of Richmond and Danville Railroad. From May, 1892, to date, Supervisor of North-western North Carolina and North Carolina Midlands R. Roads (North Carolina Division of Richmond and Danville Rail Roads).

BARUS, CARL, PH.D. (Associate), ... 1877.
National Museum, Washington, D. C.

BAXTER, GEORGE STRONG, A.B., E.M., ... 1868.
17 Broad Street, New York City.
1879-1879, Civil and Mining Engineer. 1880, Cashier N. P. R.R. 1890, Treasurer N. P. R.R.

BEARD, JAMES THOM, E.M., C.E., ... 1877.
Address unknown.
1879–80, Assistant Engineer, East River Bridge.

BEEBE, ALFRED L., PH.B., ... 1880.
21 W. Fifty-second Street, New York City.
1880–1887, inclusive, Private Assistant to Prof. Ricketts, School of Mines, New York, in general analytical work, especially Mineral Analyses. Also Assistant in Assaying and Fellow in Chemistry, 1881–1887, inclusive. 1888 to date, inclusive. Assistant Chemist, New York Health Department, 42 Bleecker Street, N, Y. City.

BEHRMAN, GEORGE WILLIAM, C.E., ... 1893.
201 Ross Street, Brooklyn, N. Y.

BELLINGER, HIRAM PAULDING, C.E., ... 1887.
Solvay Process Company, Syracuse, N. Y.

BEMIS, FREDERICK POMEROY, A.B., E.M., . . . 1885.
109 West 3d St., Davenport Iowa.

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BENEDICT, WILLIAM DE LIESSELINE, E.M., . . . 1874.
Welles Bld'g, No. 18 Broadway, Rooms 617 and 618, New York City.

BENJAMIN, FRANK PARKINSON, E.M., ... 1880.
Broker, 44 New Street, New York City.

BENJAMIN, MARCUS, PH.B., A.M. (Lafayette 1888) (LifeMbr.) 1878.
PH.D. (Univ. Nashville, 1889), Editor, D. Appleton & Co., No. 1 Bond Street and 640 Madison Avenue, New York City.

1878–1882, with E. B. Benjamin, dealer in Chemical Apparatus. 1882, Editor *American Pharmacist*. 1883, Editor *Weekly Drug News*. May, 1883, to June, 1885, Chemist, U. S. Laboratory, New York. 1885, Sanitary Engineer, N. Y. Board of Health. 1886–89, Editorial Staff, Appleton's *Cyclopædia of American Biography*. 1890, Editorial Staff, *Engineering and Mining Journal*, chiefly engaged in editing and preparing for the press, George F. Kunz's *Gems and Precious Stones of North America*. 1891–93, Editor of *General Guide to the United States*, *Handbook of Winter Resorts*, and *Handbook of Summer Resorts*, published by D. Appleton & Co. Editorial Staff in charge of Chemistry, Standard Dictionary, 1891–93. During 1884–86, Lecturer on Chemistry at New York Women's Medical College and Hospital for Women. At various times on editorial staffs: of *Scientific American*, 1883–89; *Independent Oil Journal*, 1886, and on technical subjects in New York *Daily News*, 1886 to date. New York *Star*, 1890–91 and *Pharmaceutical Record*, 1891, also of Appleton's *Annual Cyclopædia* since 1883. Other work includes translation of Berthelot's lectures on "Explosive Materials" (New York, 1883), authorship of *Druggist's Circular*, Prize Essay on "Disinfectants," authorship of chapters on "Mineral Paints" in *Mineral Resources of the United States*, for years 1884–86, and compilation of a book of Poems, entitled *May Time* (New York, 1889), and authorship of chapter on "Thomas Dongan and the Granting of the New York Charter," 1682–1688, and "The Development of Science in New York City," in *The Memorial History of the City of New York*, 1892. Contributor to *Scientific American* and *Supplement*, *The Chatauquan*, *Harper's Weekly*, *Popular Science Monthly*, *The Cosmopolitan*, etc. Life fellow of the London Chemical Society, and of the American Association for the Advancement of Science, and member of other Scientific Societies in this country and abroad.

BERRY, WILTON GUERNSEY, PH.B., ... 1886.
42 Bleecker Street, New York City.

1886–1889, Universities of Berlin and Heidelberg and General Chemical Research. 1889 to date, Assistant Chemist, New York Health Department.

BERRY, GEORGE, C.E., ... 1888.
78 Morton Street, Brooklyn, N. Y.

BIEN, JOSEPH RUDOLPH, E.M., ... 1887.
140 Sixth Avenue and 321 West Fifty-seventh Street, New York City.

1887–88, Topographer, U. S. Geological Survey, Survey of Geyser Basins, Yellowstone Nat. Park. 1888–90, Practice as Civil and Mining Engineer, firm of Vermeule & Bien, New York City. 1890–91, Practice as Civil and Topographical Engineer alone, New York City. At present, Secretary Julius Bien & Co., Lithographers, Engravers and Geographical Publishers.

BLACK, ALEXANDER LESLIE, E.M., ... 1890.
Madeleine Mine, Ward, Boulder County, Colorado, and 561 Carondelet Street, New Orleans, La.

1890–91, Traveling. 1891–92, Assistant in Mining-expert work in Montana and Mexico. Since November, 1892, Assistant Superintendent Madeleine Consolidated Mining and Milling Company.

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BLAKE, EDWIN MORTIMER, E.M., PH.D. (1893), . . 1890.
Fellow in Mathematics, Columbia College, New York City, and 230 Washington Avenue, Brooklyn, N. Y.

BLOSSOM, FRANCIS, C.E., ... 1891.
Westinghouse, Church, Kerr & Co., 17 Cortlandt Street, N. Y. City, and 440 Henry St., Brooklyn, N. Y.

1891-92, Engineer C. W. Hunt Co. 1892, Assistant Engineer Equity Gas Works Construction Company. 1893, as above.

BLYDENBURGH, CHARLES EDWARD, A.B., A.M., E.M., . 1878.
Mining Expert and Prospector, Box 189, Rawlings, Wyoming.

BODELSEN, OSCAR, E.M., ... 1884.
Consolidated Gas Co., 1547 Broadway, and 309 W. One Hundred and Twenty-seventh Street, New York City.

BŒCKLIN, WERNER, JR., C.E., ... 1891.
228 West Thirty-eighth Street, New York City.

BOOK, DWIGHT DANA, C.E., E.E. (1892), ... 1890.
159 Washington Park, Brooklyn, N. Y.

BOORÆM, ROBERT ELMER, M.E. (Life Member), . . 1878.
34 West 11th St., New York City.

1879, Assayer, general work in Leadville, Colorado. 1880–87, Assistant Superintendent, afterward Manager, Evening Star Mining Co., Morning Star Consolidated Mining Co. and others at Leadville, Colorado, Lead-silver Mines. Also in charge Farwell Con. M. Co., Gold Mines at Independence, Colorado. 1887–90, General Manager Blue Bird Mining Co., Ltd., Butte, Montana, Operating 90-Stamp Mill, Dry Crushing, Chloridizing, Amalgamating Process. 1891, General Consulting Mining Engineer and Consulting Director in Gold, Silver, and Lead-Mining Companies, of which a Specialty is made. Also Mine Operator and Owner, Silver Mines at Aspen, Colorado.

BOYD, RICHARD CHARLES, PH.B., A.M. (1892), . . 1891.
50 Charles St., New York City.

BRADLEY, STEPHEN ROWE, JR., PH.B., ... 1890.
45 Broadway, New York City, and Nyack, N. Y.

July, 1891 to-date, Secretary and Treasurer Union Electric Co.

BRASCHI, VICTOR MANUEL, PH.B., E.M., C.E., . . 1881.
Apartado 830, City of Mexico, Mex.

June, 1884, to October, 1884, Inspector of New York Tenement House Commission. October, 1884, to May, 1885, Interpreter and Sec'y to Gov. Chilian Commissioner to Visit and Report on American Mining and Smelting. May, 1885, to October, 1885, Employed by Rend-Rock Powder Co. in Flood Rock Explosion Work. October, 1885, to January, 1889, Assistant Consulting Engineer and in Charge Foreign Business, Rand Hill Co. January, February, March, 1889, Reporting on Mines in Mexico for above Co., and for one year past engaged in introducing Rand Rock Drilling Machinery in Mexican Mines. Mexico, April 2, 1891.

BRERETON, THOMAS J., A.B., 1879, C.E., . . . 1883.
Engineer Cumberland Valley Railway, Chambersburg, Pa.

1879, Rodman on Location of Redstone Br. P. R. R. 1880 and 1881 (Summers) on New York State Geodetic Survey of Adirondacks. 1883–85, Leveller P. R. R. Clearfield Co. Surveys and Construction. On Corps of Engr. M. of W. P. R. R. 1888–89.

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Assistant Supervisor, P. R. R. 1890–92, Supervisor Tyrone Div., P. R. R. 1893, Engineer Cumberland Valley Railway.

BREWSTER, HENRY DRAPER (Associate), ... 1883.
Address unknown.

BRITTON, NATHANIEL LORD, E.M., PH D., . . . 1879.
Columbia College, School of Mines, New York City.

Assistant of Geology, School of Mines, 1879–1887. Instructor in Botany, Columbia College, 1887–1890. Adjunct Professor of Botany, Columbia College, 1890–1891. Assistant, Geological Survey of New Jersey, 1880–1887. Botanist, Geological Survey of New Jersey, 1881–1890. Field Assistant, U. S. Geological Survey, 1882. Professor of Botany, 1891. Specialty—Systematic Botany.

BROSNAN, FRANCIS XAVIER, C.E., ... 1891.
146 W. Seventy-fourth Street, New York City.

BROWN, FRANCIS G., E.M., ... 1867.
Merchant, 15 Whitehall Street and 462 Lexington Avenue, N. Y. City.

BROWNING, JOHN H. BROWER, M.D. (Associate), . . 1880.
120 E. Thirty-fourth Street, New York City.

College of Physicians and Surgeons of City of New York, in year 1882. Afterwards Assistant Physician, New York City Insane Asylum, Ward's Island, 1882–83. House Physician and Surgeon to St. Francis Hospital, 1883–85. At date, Member County Medical Society of New York, Member Physicians' Mutual Aid Association, Fellow American Geographical Society, and Assistant to Chair in Surgery, New York Polyclinic, Medical Examiner for Presbyterian Board of Foreign Missions, General Practitioner of Medicine and Surgery.

BRUGMAN, WILLIAM FREDERIC, PH.B., ... 1880.
One Hundred and Forty-fourth Street and Southern Boulevard, New York City, and Los Angeles, Cal.

BRYCE, WILLIAM, JR., PH.B., ... 1884.
40 W. Fifty-fourth Street, New York City.

BUCKLEY, CHARLES RAMSAY, A.B., A.M., E.M., . . 1877.
29 Broadway, New York City.

BULLMAN, CHARLES, PH.B., ... 1883.
Mining Engineer, *Engineering and Mining Journal*, 27 Park Place, New York City, and Plainfield, N. J.

1883. Tutor in Stoichiometry, Chemist Putnam Company Chemical Works. 1884–1885–86, Venezuela; phosphates, copper, sulphur. 1887, French Guiana; phosphates. 1888, 1889–90, North Carolina, Georgia, Colombia, S. A. (2); gold and platinum. 1891, Sandwich Islands; phosphates. California (2); gold and irrigation. 1892, New Jersey; copper and graphite. 1892–93, Editorial Staff *Engineering and Mining Journal;* also Translator and Editor of *Mining Laws of the Republic of Colombia*, and Author of *Platinum* and *South America* in "The Mineral Industry."

BURDEN, HENRY, 2d., A.B., PH.B., ... 1892.
Cazenovia, N. Y.

BURNS, ABRAHAM LINCOLN, E.M., ... 1887.
3 Worth Street, New York City, and 297 Halsey Street, Brooklyn, N. Y.

Since November, 1887, with Messrs. Jabez Burns & Sons (Millwrights and Machinists, and Manufacturers of Patented Machines for Treating Coffee and Spices). Since July, 1890, in above firm. Professional work has been general shop draughting and

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machine design, and arranging machines and power transmission in coffee establishments.

BURNS, ELMER Z., E.M., ... 1887.
Niagara Falls, N. Y.

1887-88. Engineer and Chemist for The Pittsburgh and Lake Angeline Iron Co. 1889-90, Assistant Electrician for the United States Electric Light Company. 1890-1891, Assistant Electrician for the Mather Electric Company. 1891-93. City Engineer of Niagara Falls, and Consulting Engineer for the Lewiston and Youngstown R. R. Company, for the North Tonawanda Street Rail Road Company, and for the Niagara Falls and Suspension Bridge Rail Road Company.

BURRITT, WILMOT WOODWARD, PH.B., ... 1884.
Chemist, Englewood, N. J.

BUSH, EDWARD RENSHAW, E.M., ... 1881.
Mining Engineer, with Ricketts & Banks, 104 John Street, N. Y. City.

BUTLER, NATHANIEL, E.M., ... 1880.
51 Cedar Street, Room 8, New York City, and Glen Ridge, Bloomfield, Essex Co., N. J.

1880-1882, U. S. Harbor Improvement and Railroad Engineering. 1882-1888, Surveyor for Barlow's Insurance Surveys. 1888-1891, Superintendent of Barlow's Insurance Surveys.

BUTLER, WILLIAM CURTIS, M.E., ... 1887.
Everett, Washington.

1887-1889, Assayer, El Paso Smelting Co., El Paso, Texas. 1889-1890, Chemist, afterward Assistant Superintendent, Arkansas Valley Smelting Co., Leadville, Colo. 1890, Chemist, now Assistant Manager, Aurora Iron Mining Co., Superior Mining Co., Comet Mining Co., Palone Iron Mining Co., Penokee and Gogebic Development Co. (Operating Colby and Tilden Mines). Also in charge Ironwood Electric Co., Gogebic Electric Co. 1892, Superintendent Monte Cristo Mining Co., Seattle, Washington.

BUTLER, WILLARD PARKER, E.M., LL.B. (Life Member), 1878.
Counsellor at Law and Solicitor of Patents, 59 Wall Street, New York City.

C.

CALMAN, ALBERT, PH.B., PH.D., ... 1882.
332 W. Fifty-sixth Street, New York City.

CANFIELD, AUGUSTUS CASS, E.M., ... 1877.
27 Fifth Avenue, New York City.

CANFIELD, FREDERICK A., A.B., A.M., E.M., . . . 1873.
Mining Engineer, Dover, N. J.

CARSON, JAMES PETTIGREW, E.M., ... 1868.
147 West Forty-second Street, New York City.

CASAMAJOR, GEORGE H., C.E., ... 1892.
372 Greene Avenue, Brooklyn, N. Y.

CASEY, EDWARD PEARCE, C.E., PH.B., (1888), . . 1886.
Architect, 171 Broadway and The Alpine, 55 West Thirty-third Street, New York City.

With McKim, Mead & White, architects, New York City, until January, 1890.

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Abroad, and Student in L'Ecole National des Beaux Arts, Paris, from February, 1890, until September, 1893. Five mentions in Architecture, and a medal in Modeling. At present Architect, 171 Broadway, New York City.

CAULDWELL, JOHN BRITTON, C.E., ... 1877.
Century Club, 7 West Forty-third Street, New York City.

CHANNING, JOHN PARKE, E.M., ... 1883.
Box 27, Iron Mountain, Michigan.

1883, Chemist Hudson River O. and I. Co. 1884, with S. E. Cleaves & Son, Manufacturers of Mining Machinery, Houghton, Mich. 1884–1885, Assistant Managing Engineer Tamarack Mine, Calumet, Mich., Dep. Comm. Mineral Statistics, Michigan. 1885–1886, Superintendent Honduras Land and Navigation Co. 1886–1887, Exploring for iron on the Gogebic Range, and Managing Engineer for Milwaukee L. S. and Western Railway, Superintendent Iron Belt Mine. 1887–1890, Inspector of Mines, Gogebic Co., Mich. 1890 to date, Superintendent East New York Iron Co., Ishpeming, Mich.

CHAZAL, PHILIP EDWARD, A.B., E.M., ... 1881.
68 Meeting Street, Charleston, S. C.

1881–1883, Prospecting in Northwest Georgia. 1883–1889, State Chemist of South Carolina. 1889 to present, Partner in Shepard Laboratory, specialties Phosphate and Fertilizer Analysis and examination and reporting on Phosphate lands (in South Carolina and Florida).

CHESTER, ALBERT HUNTINGDON, A.M., E.M., SC.D., PH.D., 1868.
Professor of General and Applied Chemistry, Rutgers College, and 64 College Avenue, New Brunswick, N. J.

Professor of Chemistry at Hamilton College from 1870 and Mineralogy from 1878 to 1891. Conducted the Analytical Laboratory there from 1871. Chemist New York State Board of Health, 1882. Examined and reported on mines of iron, gold, silver, lead and zinc, in Michigan, Maine, Ontario, Arkansas, Colorado, Utah, Nevada, California, and Nova Scotia. Analytical work has been largely in two lines, viz., for iron-blast furnaces and of paints and varnishes. Field work has been, a great part of it, in the iron mines of Minnesota and the gold mines of Colorado.

CHURCH, ELIHU DWIGHT, JR., E.M., ... 1887.
Church & Co., 36 Ash Street, and 127 Milton Street, Brooklyn, N. Y.

1887–1888, Fellow Qualitative Analysis, School of Mines. 1888–1889, Assistant Superintendent of Lead Mine and Concentrating Works. 1889–1891, with Church & Co., in charge of experimental plant.

CHURCH, JOHN ADAMS, A.M., E.M., PH.D., . . . 1867.
Room 64, 40 Wall St., New York City. Cable address, Scotist, N. Y.

CLARK, DIEGO LOMBILLO, C.E., ... 1890.
Cardenas, Cuba.

CLARK, EDMUND (Associate), ... 1892.
George and Main Streets, Braddock, Pa. Assistant Chemist, Homestead Steel Works, Munhall, Pa.

CLARK, EDWIN PERRY, E.M., ... 1880.
Title Guarantee and Trust Co., 26 Court Street, and 425 Fifth Street, Brooklyn, N. Y.

1880–1883, Engineer and Surveyor for Silver-Lead Combination, and Robert E. Lee Mining companies, Leadville, Colo. 1883–1884, Medical student. 1884 to date, Assistant Superintendent and afterwards Superintendent Title Guarantee and Trust Company, 55 Liberty Street, New York, and 26 Court Street, Brooklyn. In charge of

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construction and maintenance of locality-indexes of Real Estate Records of New York, Kings and Westchester counties, N. Y.

CLARK, FRANKLIN SINCLAIR, E.M., PH.D., . . . 1885.
Carolina Oil and Creosote Co., Wilmington, N. C., and 527 Madison Avenue, New York City.

1885-1887, Chemist to Fernoline Chemical Co., Charleston, S. C. 1887 to date, Proprietor of Southern Chemical Works and consulting chemist for the Carolina Oil and Creosote Co., Wilmington, N. C. Specialty, Distillation of Wood and refining products and creosoting wood.

CLARK, GEORGE HALLETT, C.E., ... 1893
59 E. Sixty-seventh Street, New York City.

COLBY, ALBERT LADD, PH.B., ... 1881.
Bethlehem Iron Co., South Bethlehem, Pa.

1881-1883, Assistant to Prof. C. F. Chandler on New York State Board of Health Bureau of Chemical Analysts. 1883-1886, Instructor in Quantitative analysis and Chemical Philosophy in the Lehigh University, South Bethlehem, Pa. 1886-92, Head Chemist of the Bethlehem Iron Co. 1893 to date, Metallurgical Engineer same Company, South Bethlehem, Pa. Specialty, Metallurgy of Iron and Steel.

COLBY, CHARLES EDWARDS, E.M., C.E., ... 1877.
Adj. Professor Organic Chemistry, Columbia College School of Mines, New York City.

COLE, HAROLD MORRIS, E.M., C.E., ... 1887.
Care of Helena & Livingston S. & R. Co., Wickes, Montana.

COLT, STOCKTON BEEKMAN, PH.B., ... 1888.
33 E. Seventeenth Street, and 29 E. Twenty-eighth Street, New York City.

1888-1891, in office of G. P. Post, architect, as above.

COLTON, CHARLES ADAMS, E.M., ... 1873.
21 W. Park Street, and 57 Broad Street, Newark, N. J.

1873-1882, Assistant in Mineralogy, School of Mines, Columbia College, New York. 1882-1884, Professor of Chemistry and Mineralogy, Rose Polytechnic Institute, Terre Haute, Indiana. 1884 to date, Director and Instructor in Chemistry and Physics, Newark Technical School.

CONANT, HENRY DUNNING, E.M., ... 1886.
P. O. Box 16, Mount Vernon, N. Y.

1886-1888, Assistant Engineer Tamarack and Osceola Mines, Lake Superior, and H. and C. R.R. 1888-1889, Assistant Engineer on Preliminary of Northern Michigan Railroad. 1889, Assistant in Chief Engineer's Office, Buffalo and Geneva Railway. 1889-91, Assistant and Resident Engineer Norfolk and Western Railroad, in charge of Preliminary Location and Construction. 1891, Engineer Coeburn Land and Improvement Co. 1893, Assistant Engineer N. Y., N. H. & H. Ry.

CONGDON, ERNEST ARNOLD, PH.B., ... 1887
Drexel Institute Arts, Science and Industry, and 1409 Locust Street, Philadelphia, Pa.

1887-1889, Chemist to Champlain Fibre Co., Willsborough, New York. 1889, Studied at the University of Berlin, Summer Semester. 1889 to date, Instructor in Qualitative Analysis and Assaying at the Lehigh University. 1891, Professor of Chemistry in the Drexel Institute of Arts, Sciences and Industries, Philadelphia, Pa.

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CONNELL, HEWLETT RAISTON, C. E., ... 1890.
140 Pierrepont Street, Brooklyn, N. Y.

COOPER, WILLIAM HAMILTON, PH.B. (Life Member), . 1882.
Address unknown.

CORCORAN, JOHN THOMAS, E.M., S.E., ... 1884.
131 Smith Street, Brooklyn, N. Y.

CORNELL, GEORGE BIRDSALL, E.M., C.E., ... 1877.
29 Broadway and 46 West Forty-eighth Street, New York City.

Assistant Engineer Manhattan Elevated Railway. Engineer for Contractors for structure Manhattan Elev. Ry. Assistant Engineer Brooklyn Elev. Ry. Assistant Engineer New York, Chicago and St. Louis R. R. Principal Assist. Engineer Rochester and Pittsburgh Ry. Inspector and Engineer Bridge Dept. N. Y., West Shore and Buffalo Ry. Principal Assist. Engineer Brooklyn Elevated Ry. Chief Engr. Brooklyn Elev. Ry. Chief Engr. Union Elevated Ry. of Brooklyn. Chief Eng. Chicago and South-side Elev. Ry. Chief Engr. J. B. & J. M. Cornell Iron Works. At present Chief Engineer East River Bridge Company.

CORNWALL, HENRY BEDINGER, A.B., A.M., E.M., PH.D., 1867.
Professor Analytical Chemistry and Mineralogy, College of New Jersey, Princeton, N. J.

CORNWALL, HARRY CLAY, E.M., ... 1879.
Commonwealth Insurance Co., Nassau Street, New York City.

COX, JENNINGS STOCKTON, JR., MET. ENG., . . . 1887.
Monte Cristo, Washington, and 76 W. Sixty-eighth St., N. Y. City.

1887, Government Survey for Canal between Harlem and Hudson River. 1888–1889, Homestead Steel Works, Draughtsman and afterward Assistant Master Mechanic. 1890, Inspected construction of Steamer "Sezurania" and "Vigilancia" for the U. S. and B. M. S. S. Co., at Roach's Shipyard, Chester, Pa. 1891, Reporter for same Company on Engineering matters along the Brazil coast. 1892, with same company in New York. 1892, Assist't Superintendent Aurora Iron-Mining Company, Ironwood, Michigan. 1893, Assist. Supt. Monte Cristo Mining Co., Pride of the Mountain Mining Co., Rainy Mining Co., and United Concentration Company.

CRAMER, STEWART W., E.M. (Associate), ... 1889.
United States Assay Office, Charlotte, N. C.

Graduate of United States Naval Academy, Resigned from United States Navy September, 1888. Graduate student at School of Mines, 1888–1889. July 1, 1889 to date, Assayer in charge of the United States Assay Office, Charlotte, N. C. 1890, Special Agent of Census Office for collection of statistics on Gold and Silver mines of South. Special correspondent of *Engineering and Mining Journal* in Southern States. Occasionally report on gold and silver mines of Southern States. Specialty, Consulting Engineer on gold and silver mining in Southern States.

CROCKER, FRANCIS BACON, E.M., ... 1882.
Professor Electrical Engineering, Columbia College School of Mines, and 51 W. Twenty-first Street, New York City.

1882–1886, Electrical Engineer and Inventor. 1886–1887, Vice-President and Electrician of "C. and C." Electric Motor Co. 1887–1889, Vice-President and Electrician Crocker-Wheeler Electric Motor Co. 1889–92, Instructor in Electrical Engineering, School of Mines, Columbia College. 1892, Adj. Professor. 1893, Professor.

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CROWELL, CHARLES BURTON, PH.B., ... 1885.
Box 664, Colorado Springs, Colo.

CUSHMAN, ALEXANDER RAMSAY, PH.B., PH.D., . . 1878.
Assistant Analytical Chemistry, Columbia College School of Mines, and 128 E. Sixteenth Street, New York City.

1878–1880, Post Graduate study at the School of Mines, for degree of Ph.D. 1880–1882, in Colorado, visiting mines and smelters. 1882–1890, Engaged in pursuing chemical studies and lecturing on geology. 1890 to date, Assistant Instructor in Qualitative Laboratory at the School of Mines, Columbia College.

D.

DARWIN, HARRY GILBERT, C.E., ... 1887.
Room 18, 160 Broadway, New York City, and Glen Ridge, N. J.

June, 1887 to October, 1887, Rodman and Leveller on Railroad field work in New York State. October, 1887 to May, 1888, Draughtsman Strong Locomotive Co., New York City. August, 1888 to date, Assistant Engineer and Acting Superintendent Safety Car Heating and Lighting Co., New York City. Erection of special gas works, and equipment of railroad cars, etc.

DAVIS, CHARLES HENRY, C.E., ... 1887.
120 Broadway, New York City, 308 Walnut Street, Philadelphia, and 576 Lexington Avenue, New York City.

Expert course and Thomson-Houston Electric Co., Lynn, Mass., summer 1887. Agent, Lawyer Mann Electric Co., winter 1887–88. Supt. selling and construction New York office S. M. Elec. Co., summer and winter 1888. Agent Westinghouse Electric Company, winter 1889. Consulting and Supervising Electrical Engineer from May, 1889, to date.

DAVIS, JOHN WOODBRIDGE, C.E., PH.D., ... 1878.
Principal Woodbridge School, 645 Madison Avenue, New York City.

DEGHUÉE, JOSEPH ALBERT, PH.B., A.M. (1892), PH.D. (1893), ... 1890.
College Phys. and Surg., New York City, and 247 Harrison St., Brooklyn, N. Y.

DELAFIELD, AUGUSTUS FLOYD, PH.D. (Associate), . . 1869.
University Club, New York City.

DE LUZE, LOUIS PHILIPPE, C.E., ... 1879.
DeLuze & Emmett, New Rochelle, N. Y.

DEVEREUX, WALTER BURCHIER, A.B., A.M., E.M., . 1878.
Glenwood Springs, Colorado.

DODGE, FRANK DESPARD, PH.B., PH.D., . . . 1888.
Dodge & Olcott, 137 Water St. and 111 Montague St. Brooklyn, N. Y.

From October, 1891, to date, Chemist, with Dodge & Olcott, manufacturers of essential oils, etc.

1888–90, Fellow in Chemistry, Assistant in Organic Laboratory, School of Mines. 1890–91 (studying in Germany).

DODSWORTH, WALTER ALBERT, PH.B., ... 1888.
Pratt & Lambert, 47 John Street, New York City, and 253 Henry Street, Brooklyn, N. Y.

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DOLAN, CHARLES FRANCIS, C.E., ... 1892.
111 East 129th Street, New York City.

DONNELL, HARRY ELLINGWOOD, PH.B., ... 1887.
Architect, R. M. Hunt, 38 Park Row, New York City.

DOUGLAS, JOHN SHEAFE, C.E., ... 1890.
Union Elect. Company, 45 Broadway and 72½ Irving Place, N. Y. City.

1890, Course Electrical Engineering, Columbia College. 1891, Crocker-Wheeler Electric Motor Company, and now Assistant Engineer Western Electric Company in Lighting Department. 1893, Superintendent of Union Elect. Co.'s Exhibit at World's Columbian Exposition, Chicago.

DOUGLASS, EDWARD MOREHOUSE, C.E., ... 1881.
Topographer U. S. Geological Survey, Washington, D. C.

DOW, ALLAN WADE, PH.B. (Life Member), . . . 1888.
Col. College, School of Mines, and 83 West Seventy-first Street, New York City.

1888–89, Honorary Fellow Quant. Laboratory. School of Mines. 1889, Chemist at Tilly Foster Mine, New York. 1889–91, Assistant Chemist of The Barber Asphalt Paving Co.

DOWNES, STANCLIFF BAZEN, C.E., ... 1882.
Fordham (opposite Harlem Railroad station), and 1071 Madison Avenue, New York City.

December, 1882, to April, 1885, Assistant, Office Topographical Engineering Department Public Parks, New York City. April, 1885, to January, 1891, Assistant Engineering Department Public Parks. April, 1886, elected Junior Member American Society Civil Engineers. January, 1891, to date, Civil Engineer, Fordham, New York City, opposite Harlem Railroad station.

DOWNS, WILLIAM FLETCHER, E.M., ... 1882.
Joseph Dixon Crucible Co., and 75 Fairview Avenue, Jersey City, N. J.

With the Joseph Dixon Crucible Co. since graduation. From June, 1882, to September, 1882, at experimental work. From September, 1882, to October, 1884, in charge of lubricating department. From October, 1884, to present time Superintendent of crucible and other departments.

DRESSER, DANIEL LEROY, C.E., ... 1889.
Merchant, 273 Church St., New York City, and Flushing, N. Y.

DRUMMOND, ISAAC WYMAN, E.M., PH.D., . . . 1878.
F. W. DeVoe & Co., William and Fulton Streets, New York City.

DUFOURCQ, EDWARD LEONCE, M.E., ... 1892.
846 Lexington Avenue, New York City.

1892–93, Assistant Superintendent Costa Rica Pacific Gold Mining Company, Punta Arenas, Costa Rica.

DUNHAM, EDWARD KELLOGG, PH.B., ... 1881.
Carnegie Laboratory, 338 East Twenty-sixth Street, New York City.

DUSENBERRY, WALTER LORTON, E.M., ... 1884.
Park Department and 361 Produce Exchange, New York City.

1884–87, miscellaneous. U. S. Coast Survey. Mining in Mexico and the west. Survey of New Parks, Westchester County, etc. 1887–89, Inspector of Masonry and

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Transit-man on New Croton Aqueduct. 1889–91, in charge of party and Assistant Engineer of Construction Department of Public Parks, New York City.

DUTCHER, BASIL H., PH.B., ... 1892.
525 Manhattan Avenue, New York City.

DWIGHT, ARTHUR SMITH, E.M., ... 1885.
Superintendent Colorado Smelting Co., Pueblo, Colorado.

1885, Assistant Assayer at works of The Colorado Smelting Company, Pueblo, Colorado. 1885 to 1888, Assistant Chemist and Chemist, except autumn of 1886, when examining and reporting on lead deposits of Cœur d'Alene region, Idaho Territory, and spring of 1889, when acting as Assistant Supt. Madonna Mine, Monarch, Colo. 1888–90, Metallurgist, and 1890 to date, General Supt. of the Colorado Smelting Co.

E.

EASTON, LANGDON CHEVES, C.E., ... 1884.
Port Harford, San Luis Obispo Co., Cal., and 344 South Grand Avenue, Los Angeles, Cal.

1885–88, Engineer Corps, Aqueduct Commission, New York City. 1889, City Surveyor's Corps, Los Angeles, Cal. 1889 and 1891, in charge of harbor improvements, Port Harford, Cal., under direction of U. S. Corps of Engineers.

EASTWICK, GEORGE SPENCER, C.E., ... 1879.
Manager American Sugar Refinery Co., 24 North Peters St., New Orleans, La., and 1425 Broadway, New York City.

EASTWICK, EDWARD PEERS, JR., PH.B., S.E., C.E. (1892), 1889.
Address unknown.

EBERHARDT WILLIAM G., M.E., ... 1891.
Richardsville, Culpepper County, Virginia; 450 W. Twenty-second St., New York City.

EDDIE, EDWARD CRITTENDEN, E.M., ... 1885.
Colorado Smelting Co., Box 8, Pueblo, Colo.

EDWARDS, RICHARD MASON, E.M., ... 1886.
Red Jacket and Houghton, Mich.

1886–87, general assay office at Houghton, Mich. 1888–89, Professor of Mining, Michigan Mining School, Houghton. 1890 to date, Mining Engineer for Tamarack, Tamarack, Jr., Osceola and Kearsarge Mining Cos., L. S., Mich.

EILERS, KARL EMRICH, E.M., ... 1889.
National Smelting and Refining Company, South Chicago, Ill., and 751 St. Mark's Avenue, Brooklyn, N. Y.

1889–91, student and travelling in Europe.

ELLIOTT, ARTHUR HENRY, PH.B, PH.D., . . . 1881.
Professor Chemistry, College of Pharmacy, Editor *Anthony's Bulletin*, 591 Broadway, New York City.

ELLIOTT, WILLIAM, PH B., ... 1880.
56 Wall St., New York City.

EMRICH, ANTON FREDERICK, E M., ... 1882.
United Smelting and Refining Co., Smelter, Mont.

1882–84, with the Tombstone Milling and Mining Co., Charleston, Arizona. 1884–

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86, Assayer, Chemist, Mine Engineer, the Colorado Smelting Co., Pueblo, Colo. 1886–88, Superintendent the Madonna Mine, Monarch, Colo. Property of the Colorado Smelting Co., Pueblo, Colo. 1888–89, Mining Engineer acting as Expert for the Montana Smelting Co., of Great Falls, Mont., in Montana, Idaho, Washington and British Columbia. 1889–90, Mining Engineer, Superintendent of Mines, Ore Buyer and Mine Manager for the Montana Smelting Co., Great Falls, Mont. 1890 to present, Superintendent and Metallurgist the United Smelting and Refining Co., Smelter, Mont.

ENGEL, LOUIS GEORGE, E.M., ... 1880.

Brooklyn Sugar Refinery, and 238 Clermont Avenue, Brooklyn N. Y.

Assistant Engineer Tilly Foster Iron Mines, Draughtsman and Superintendent of Construction Brooklyn Sugar Refinery, and Engineer.

ENGELHARDT, EUGENE NICHOLAS, E.M., . . . 1885.

Selby, Contra Costa Co., Cal.

1886, Assayer, Chemist and Assistant Superintendent Pueblo Smelting and Refining Co. 1887 and 1888, Superintendent of the same company. 1889, Assistant Superintendent Anaconda Smelting Co. From 1890 and to present time, Assistant Superintendent Selby Smelting and Lead Co.

F.

FAHYS, GEORGE ERNEST, C.E., ... 1884.

38 Maiden Lane, New York City, and 285 DeKalb Avenue, Brooklyn, N. Y.

Treasurer, Prentiss Calendar Time Co.

FALK, DAVID BEAUREGARD, C.E., ... 1882.

Savannah, Ga.

FEARN, PERCY LE ROY, E.M., ... 1889.

1326 Monadnock Bldg., Chicago, Ill.

1889–90, Assayer and Surveyor, Trinidad Mine, Costa Rica. 1890–92, Superintendent, Trinidad Mine, Costa Rica. 1892–93, Consulting Mining Engineer Illinois Fluor Spar and Lead Co.

FERGUSON, WILLIAM CUSHMAN AUGUSTINE, PH.B., . 1887.

Nichols Chemical Co., Laurel Hill Chemical Works, Laurel Hill, N. Y., and 5 Spencer Place, Brooklyn, N. Y.

From 1887 to 1888, Chemist, Fulton Sugar Refinery. From 1888 to date (1891), Chemist for Nichols Chemical Co., Manufacturers of Sulphuric, Muriatic and Acetic Acids, Alum, Salt Cake, Bisulphate Soda, Blue Vitriol, and Smelters of Copper Ore; also Manufacturers of Acid Phosphate. Work: Investigation of different questions affecting above, and also in new lines, such as Sulphate of Alumina, etc. Also analytical work.

FERRER, CARLOS FERRER, C.E., ... 1883.

39 Broad Street, New York City.

After graduation, for a few weeks on work at the School of Mines. Then under Mr. W. E. Worthen, C.E., on some work for the Water Commissioners of the State of New Jersey. From March, 1884, to January, 1887, on the Engineering Corps of the Aqueduct Commissioners, New York City, as Assistant to Engineer of Construction; Leveler in charge of field work on Section "A"; reduced to Rodman in charge of same; promoted to Assistant Engineer: resigned in January, 1887, and have since been engaged in business for my own account at above address.

FERRIS, JUNIUS COLTON, E.M., ... 1883.

Carthage, Ill.

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FEUCHTWANGER, HENRY, PH.B., ... 1882.
Room 19, 99 Franklin Street, New York City.

FIALLOS, ENRIQUE CONSTANTINO, C.E., ... 1883.
No. 27, Calle 10a, Tegucigalpa, Honduras, C. A., and care Ernest Schernikow, P. O. Box 3540, N. Y. City.

General practice in Engineering. Professor of Mathematics and Mineralogy in the University of Tegucigalpa. The most extensive practice has been as Government Surveyor of Lands and Mines.

FISHER, WILLARD, E.M., ... 1888.
Dallas, Texas, and 361 W. Fifty-sixth Street, New York City.

Draughtsman to Parsons, C.E., New York City. Assistant to Superintendent Segovia Gold Mining Co., Nicaragua. Clerk, Office of Rich Hill Coal Mining Co., Rich Hill, Mo. Engineer and Mine Surveyor, Rich Hill Coal Mining Co., Rich Hill, Mo. Prospecting for coal, Southwest Missouri, along the line of Wichilaw & Western in the interest of the Missouri Pacific Railroad. Southern Sales Agent, Coal Cos. on the lines of Missouri Pacific Railway. President Tyler S. E. Railway of Texas.

FLOYD, FREDERICK WILLIAM, C.E., E.M., . . . 1877.
539 W. Twentieth St. and 175 W. Eighty-seventh St., N. Y. City.

1877-78, Honorary Assistant in Metallurgy, School of Mines. 1878-81, U. S. Geographical Surveys, West of 100th Meridian. 1881-82, Preliminary Surveys, New Croton Aqueduct and Dam, New York. 1882, Reporting on Mines in Colorado. 1883 to date, Firm of James R. Floyd & Sons, Iron Works. Specialty, Gas Engineering and Gas Works Construction.

FOSTER, REGINALD GUY, C.E., ... 1893.
16 E. Thirty-first Street, New York City.

FOWLER, ALBERT CASIMIR, C.E., ... 1889.
Cienfuegos, Cuba.

FOWLER, SAMUEL STEWART, A.B., E.M., ... 1884.
Golden, B. C., Canada, and Room 201, 34 Clark Street, Chicago, Ill.

1885, Civil Engineering Work, New York. 1886, Assistant Superintendent, Iron Hill Mining and Milling Co., Black Hills, South Dakota. 1887, Assistant Superintendent Galena Reduction Co., Black Hills, South Dakota. 1888, Superintendent, International Smelting Works, Texas. Engineer and Assayer, Bunker Hill and Sullivan Mg. and Conc. Co., Idaho. 1889, Reporting sundry properties. 1890 to date. Superintendent Golden Mining and Smelting Co., Golden, B. C., Canada.

FOYÉ, ANDREW ERNEST, C.E., ... 1890.
Tutor in Civil Engineering, School of Mines, Columbia College, and 163 West Seventy-ninth Street, New York City.

1890-92, Engineer's office, M. W. P. R. R. 1892 to date, as above.

FRANK, JEROME WILLIAM, PH.B., ... 1888.
Standard Varnish Works, 207 Avenue D, New York City.

FREEDMAN, WILLIAM HORATIO, C.E., ... 1889.
120 W. One Hundred and Twenty-fifth Street, New York City.

Post-graduate in Elect. Engineering, 1889-91. John Tyndall Fellow, 1891-92. Tutor in Elect. Engineering, since 1892. Additional degree of E. E. in June, 1891.

FRIEDMAN, SAMUEL, C.E., ... 1892.
City Engineer's Office, Niagara Falls, N. Y.

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FURMAN, HOWARD VAN FLEET, E.M., ... 1881.
510 Peoples Bank Bld'g., Denver, Col.

1882–88, Assayer and Chemist and Foreman, Germania Lead Works, Utah. Chemist, Globe Smelting and Refining Co., Denver. Assistant Superintendent, Billings Smelter, Socorro, New Mexico. Superintendent, Bailey Smelter, Denver, Colo. 1888–91, some experience as Consulting Engineer and Metallurgist.

G.

GARLICHS, HERMAN, E.M., ... 1880.
Omaha and Grant S. and R. Co., Omaha, Neb.

1880–83, Surveying and Reporting on Mines in Colorado. 1883–87, Assistant Superintendent, Aurora S. & R. Co., Aurora, Ill. 1887, and to the present, Superintendent, Refining Department, Omaha and Grant S. and R. Co. Specialty, Silver and Lead Smelting and Refining.

GIFFORD, STANLEY DEVOL, E.M., ... 1889.
Butte City, Montana, and Tuckahoe, N. Y.

GOING, CHARLES BUXTON, PH.B., ... 1882.
President Cincinnati Desiccating Co., Cincinnati, and Glendale, Ohio.

GOLDSCHMIDT, SAMUEL ANTHONY, A.B., A.M., E.M., PH.D.
(Life Member), ... 1871.
Treasurer Columbia Chemical Works, 43 Sedgwick St., Brooklyn, N. Y., and New York City.

Assistant Ohio Geological Survey, 1871. Chemist and Assistant Inspector of Fertilizers, Savannah, Ga., during winters of 1871–75. During summers, Assistant to Dr. Chandler, Inspector New York Board of Health, 1873–75. Reporting on Guano Islands, South Pacific, 1876. General Consulting Practice, 1876–80. Inspector Offensive Trades, New York Board of Health, 1879–88. Treasurer and Manager Columbia Chemical Works, 1880 to date. Specialty, Ammonia Manufacture.

GOOD, GEORGE MCCLELLAND HOUTZ, E.M., . . . 1886.
Mining Engineer, Osceola Mills, Clearfield Co., Pa.

1892, Mining Engineer to The United Collieries Company. 1893, Assistant Gen'l Manager of the same.

GOODWIN, EDWARD, E. M., ... 1891.
Tombstone Mill and Mining Company, Tombstone, Arizona, and Governor's Island, N. Y.

GORDON, JOHN, JR., E.M., ... 1871.
Merchant, Edward Johnston & Co., 62 Sas Pedro, Rio de Janeiro, Brazil, and G. O. Gordon, 69 Wall St., N. Y. City.

GOSLING, EDGAR BONAPARTE, E.M., C.E, ... 1884.
Windsor Hotel, New York City.

Tutor in Mathematics, Columbia College from 1884 to 1885. Draughtsman and afterwards Assistant Engineer in Department of Docks, New York City, 1886–88. In Manufacturing Business in Paris, France, 1888–89. Tutoring in Mathematics and Engineering Branches in New York, and Superintending building of houses, introducing Culm-burning Furnace in U S., 1889–91. On Construction and Public Works at the Suez Canal, Egypt, to build two villages on same in artificial stone (Beton Coignet).

GRAFF, CHARLES EVERETT, E.M., ... 1885.
Address unknown.

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1885–87, Assistant Engineer, Central Entre Riano Railroad, Argentine Republic, S. A. 1887–88, Engineer, Arizona Union Mining Co., Prescott, Arizona. 1888–90, Manufacturing Work, Binding Twine and Reapers. 1890–91, Engineer, Eagle Oil Co.

GRATACAP, LOUIS POPE, PH.B., ... 1876.
Curator American Museum Natural History, New York City, and West New Brighton, S. I.

GREENLEAF, JAMES LEAL, C.E., ... 1880.
Adj.-Professor Civil Engineering Columbia College School of Mines, and Llewellyn Park, West Orange, N. J.

Special Agent for Tenth Census for Water-power from 1880 to 1882. Since instructing in engineering, civil and sanitary, in School of Mines, Columbia College. 1891, Adjunct Professor Civil Engineering, Columbia College.

GRIFFIN, SAMUEL PALMER, JR., E.M., ... 1884.
Building Dept., Eighteenth St. and Fourth Ave., and 449 Park Ave., New York City.

GRISWOLD, WILLIAM TUDOR, C.E., ... 1881.
U. S. Geological Survey, Washington, D. C., and Boise City, Idaho.

GROSS, LOUIS NATHAN, B.S., E.M., ... 1884.
Merchant and 38 East Fifty-eighth Street, New York City.

GUDEMAN, EDWARD, PH.B., PH.D., ... 1887.
American Glucose Co., Peoria, Ill., and P. O. Box 3001, N. Y. City.

Student at the Universities of Berlin and Göttingen, 1887–89. Private Assistant with Dr. C. F. Chandler, and Honorary Assistant at the School of Mines. 1889 and 1890, Professor of Chemistry in charge of the Department of Chemistry, Dyeing and Pottery at the Pennsylvania Museum and School of Industrial Art, Philadelphia, Pa.

GUDEWILL, CHARLES EDWARD, C.E, ... 1890.
2 West Forty-seventh Street, New York City, and Montreal Water and Power Co., Imperial Bld'g., Montreal, Canada.

GUITERMAN, EDWARD WOLF, PH.B., ... 1889.
Passaic Print Works, Passaic, N. J., and 335 West Fifty-eighth Street, New York City.

1890 to date, Chemist above works.

H.

HAASIS, DUNBAR FERDINAND, E.M., ... 1883.
U. S. S. "Gedney," Box 173, and 83 Rector St., Perth Amboy, N. J.

1883–84, Inspector of bridge work, Stony Point, New York. 1885–88, Assayer and Chemist, afterwards General Manager Parral Mining and Milling Co. (silver), Mexico. 1889, with Corps of Engineers, U. S. A., on New York Harbor Improvements. 1890 to date, Engineer Marion Phosphate Co., Florida, and Engineer Hamburg Phosphate Co., Florida. Surveying, prospecting and reporting on phosphate deposits. 1892–93, with U. S. Engineers in charge construction Concrete Fortifications. In charge of Harbor Improvements.

HALE, ALBERT WARD, A.B., A.M., E.M., . . . 1867.
Department Public Works, East Twenty-fourth Street, New York City.

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HALL, ROBERT WILLIAM, E.M., ... 1876.
University Building, Washington Square, New York City.

From 1879 to 1888, Chemist to the American Gas Fuel and Light Company and to some associated companies. Since the autumn of 1888, Acting Assistant Professor of General Chemistry in the University of the City of New York. Since the autumn of 1890, also Acting Professor of Analytical Chemistry in the same institution.

HALLOCK, ALBERT PETER, PH.B., PH.D., . . . 1880.
440 First Avenue and 434 Lenox Avenue, New York City.

June, 1880, to October, 1880, with Dr. P. de P. Ricketts. October, 1880, to November, 1887, Chemist Consolidated Gas Co. November, 1887, to January, 1889, in the shell lime business. January, 1889, to date, Chemist to Carl H. Schultz, Mineral Water Factory. Specialty, Gas and Mineral Water Chemistry.

HANKINSON, ALBERT WORTHINGTON, C.E., . . . 1893.
114 West Forty-fifth Street, New York City.

HANNA, GEORGE BYRON, A.B., E.M., ... 1868.
Charlotte, N. C.

Chemist and Assistant Geologist North Carolina Geological Survey. Melter and Assistant Assayer U. S. Assay Office, Charlotte, N. C. Also Consulting Mining Engineer and Chemist, etc.

HARDING, GEORGE EDWARD (Associate), ... 1867.
Architect, 40 Exchange Place, New York City.

HARRINGTON, THOMAS HENRY, C.E., ... 1889.
Engineer section U. S. Gov't Bldg., Jackson Park, Ill., and Westchester County, N. Y.

July, 1889, to March, 1893, Inspector Clerk and General Superintendent on U. S. Works, Flood Rock, Hell Gate, East River, N. Y. April, 1893, in charge of Exhibit of River and Harbor Improvements from New York City and Hudson River, at World's Columbian Exposition, Chicago.

HARRIS, EDWIN, PH.B., ... 1889.
Globe Steam Heating Co., 412 N. Eleventh St., St. Louis, Mo.

1889-90, Chemist of the Camden Consolidated Oil Company. 1890 to date, Chemist Camden Consolidated Oil Company and agent for oil, mineral and timber lands in West Virginia and Ohio. Chemist to the Phosphorus Works of J. J. Allen's Sons, 2: Chestnut St., Philadelphia, 1892-93.

HATHAWAY, NATHANIEL, PH.B., ... 1879.
Swain Free School, and 43 Elm Street, New Bedford, Mass.

1879-80, Booth and Edgar Sugar Refinery. 1880-83, Private Assistant to Dr. E. Waller, New York. 1883-91, Teacher of Chemistry and Physics Swain Free School, New Bedford, Mass., and general analytical work.

HAWLEY, JOHN FRANCIS, C.E., ... 1891.
Apartado 172, Guatemala, C. A.

HÉBERT, OCTAVE BRITTON, C.E., ... 1888.
125 East Seventy-fourth Street, New York City.

HEINSHEIMER, ALFRED MAURICE, C.E., ... 1887.
Kuhn, Loeb & Co., 30 Nassau Street, and 71 East Ninetieth Street, New York City.

HENDRICKS, HENRY HARMON, PH.B. (Life Member), . . 1880.
Hendricks Bros., 49 Cliff Street, New York City.

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HERCKENRATH, WALTER AUGUSTUS, A.M., C.E., . . 1892.
266 Clinton Street, Brooklyn, N. Y.

1892-93, Erie City Iron Works and with City Engineer on pavements and sewers; Wilmington, Vt., on Railway and General Engineering; Inspector U. S. Dredging Operations, Gowanus Bay.

HEWLETT, JAMES MONROE, PH.B., ... 1890.
McKim, Mead & White, 1 W. Twentieth Street, and 68 Remsen St., Brooklyn, N. Y.

HILDRETH, RUSSEL WADSWORTH, E.M., ... 1885.
R. W. Hildreth & Co., Inspector and Bridge Expert, No. 2 Wall Street, and 25 Madison Avenue, New York City.

HILDRETH, WALTER EDWARDS, C.E., E.M., . . . 1877.
Metropolitan Hotel, 584 Broadway, New York City.

HILL, WILLIAM, C.E., ... 1882.
Assistant Superintendent Collins Company, Box 196, Collinsville, Conn.

One year practical experience in manufacture of crucible steel. Two years draughtsman and assistant to master mechanic of company manufacturing crucible steel, bar-iron, edge tools, plows and wrenches. Engineer in charge of reconstruction of dam 600 feet long, 32 feet high, at Otis, Mass. 1886 to date, Assistant Superintendent for the Collins Company, employing about 650 men, manufacturing principally edge tools.

HINMAN, BERTRAND CHASE, PH.B., A.M. (1892), . . 1890.
929 Flushing Avenue, Brooklyn, and Mansville, Jefferson County, N. Y.

Since June, 1890, Chemist to the Iron Clad Manufacturing Company, engaged in the manufacture of sheet-iron enamelled ware.

HOLBROOK, FRANCIS NEWBERRY, C.E., ... 1876.
42 Pine Street, New York City, and Box 395, Tarrytown, N. Y.

From fall, 1876, to spring, 1880, Assistant Assay Laboratory School of Mines. Spring and Summer on Geological Survey, West Texas. Then to 1884, spring, Superintendent Corralitos Co., Chihuahua, Mexico. 1884–87, expert work, office El Paso, Texas. Summer and fall, 1887, Superintendent of United Verde Copper Company, Arizona. 1888, spring, on geological work for the Southern Pacific Company in West Texas. Summer and fall, running gold mine and mill for self in Arizona, 1889–90, Manager for U. S. Circuit Court in suit between the Con. Kansas City Smelting and Refining Company and the Guadalupe Company, in Nuevo Leon, Mexico. 1890 to February, 1891, employed by the Compañia Métalurgica Mexicana. March and April, 1891, charge of copper smelter, Tucson, Arizona. Expert work until 1892, when returned to Comp. Metal., Mexico.

HOLDEN, EDWARD HENRY, C. E., ... 1878.
1074 Boston Avenue, New York City.

HOLLERITH, HERMAN, E.M., PH.D. (1890), . . . 1879.
Electrician and Expert, 501 F. St., Washington, D. C.

HOLLICK, ARTHUR, PH.B., ... 1879.
Columbia College, and Box 105, New Brighton, N. Y.

Superintendent Mexican Mine, Mariposa, Cal., 1880. New York City Health Department Inspector from 1881–90. Sanitary Engineer from 1890–91. Special Inspector, 1892, New York State Board of Health. Special Expert and Inspector of

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Offensive Trades, both in consultation and field work, from 1883 to date. Board of Health, Village of New Brighton; 1886–92, a member of the Board. Board of Health, Long Island City, Sanitary Adviser, 1890. In general practice as a sanitarian from 1883 to date. U. S. Geological Survey—engaged in collecting specimens in the Territories, in 1882. Appointed Fellow in Geology, Columbia College, January, 1890; reappointed, 1891; Assist., 1892. Recording Sec'y Torrey Botanical Club, N. Y., 1883–88. Corresponding Secretary Natural Science Association of Staten Island, 1881 to date. Associate Editor, *Bulletin*, Torrey Botanical Club, 1888 to date.

HOLLIS, HENRY LEONARD, E.M., ... 1885.

1232 The Rookery, Chicago, Ill., and 804 Perry-Paine Bldg., Cleveland, O.

1885, Assistant Chemist Edgar Thomson Steel Works. 1885–87, Assistant Chemist, North Chicago Rolling Mill Company. 1887–90, Chief Chemist, North Chicago Rolling Mill Company, which, in 1889, became by consolidation part of the Illinois Steel Company. 1890, member of firm of Rattle, Nye & Hollis, Analytical Chemists and Mining Engineers. 1893, Member of firm of H. L. Hollis & Co., Analytical Chemists and Mining Engineers.

HOLLIS, WILLIAM, C.E., ... 1878.

Box 109, Eagle Pass, Texas. Agent for Alamo and Coahuila Coal Cos.

HOLT, MARMADUKE BURRELL, E.M., ... 1889.

Colorado Smelting Company, Pueblo, Colo., and 287 Lexington Ave., New York City.

1889–90, Student in course of Electrical Engineering, School of Mines. 1890–91, with Aspen Mining and Smelting Company, serving as Mining and Electrical Engineer. 1891 to fall of 1892, Agent and Electric. Engineer with the "C. and C." Electric Motor Co., N. Y. City and Denver. 1892–93, Assayer Colorado Smelting Co., Pueblo, Colo.

HOOKER, WILLIAM AUGUSTUS, A.B., A.M., E.M., . . 1869.

Hooker & Lawrence, 145 Broadway, New York City.

HOOPER, FRANK CYRUS, MET. ENG., ... 1890.

American Graphite Co., Ticonderoga, N. Y.

1890–1891, Assistant Engineer De Lamar Mining Co., Limited. 1892–93, American Graphite Co.

HOPKE, THEODORE M., PH.B., ... 1880.

Linden Steel Co., Pittsburgh, Pa., and Hastings on Hudson, N. Y.

August, 1889, November, 1881, Analytical Chemist with Ledoux & Co., New York. November, 1881 to November, 1885, Member of the firm of Elliott, Hopke & Mattison, Analytical and Consulting Chemists and Assayers. July, 1886 to November, 1889, Chemist for Linden Steel Co., of Pittsburgh, Pa., also had charge of Physical testing department. November 1889 to date, Manager Open-Hearth department of above Co., having full charge of manufacture of all grades of steel made by the company, also building of open-hearth furnaces.

HORNE, WILLIAM DODGE, PH.B.,. . . . . 1886.

Instructor Analytical Chemistry, Rutgers College, New Brunswick, N. J.

June, 1886 to December, 1887, Chemist to Fulton Sugar Refinery, Brooklyn, N. Y. October, 1887 to December, 1887, Assistant Instructor in Chemistry, School of Mines, Columbia College. December 1887 to June, 1888, Chemist to St. Louis Sugar Refinery, St. Louis, Mo. October, 1888 to October, 1889, Chemist to Standard Sugar Refinery, Boston, Mass. November, 1889, to present time, General Analytical Chemistry, Lab-

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oratory and office in New Brunswick, N. J. January, 1890, to present time, Chemist to Delaware Sugar House, Philadephia, Pa. January, 1891, to present time, Instructor in Analytical Chemistry in Rutgers College, New Brunswick, N. J.

HOWE, EPENETUS, E.M. (Life Member), ... 1886.
Cia Constancia, Sierra Mojada, Mexico, and North Salem, N. Y.

Assayer and Chemist with the El Paso Smelting Co., and the Argentine Works. Kansas, 1887–1889, and with Lacia Constancia Esmeralda Sierra Mojada Coahuila. Mexico, 1889.

HOYT, WALTER LOWRIE, E.M., C.E., ... 1876.
St. Louis Smelting and Refining Company, St. Louis, Mo.

1877–1880, Chemist and Metallurgist at Smelting Works in Utah, Montana and Colorado. 1880–1884, Metallurgist with Omaha & Grant Smelting and Refining Co., Omaha, Neb. 1884, Mining Engineer with El Callao Gold Mining Co., Venezuela, S. A. 1885–1891, Superintendent St. Louis Smelting and Refining Co., St. Louis, Mo.

HUMBERT, WILLIAM SCOTT, E.M., ... 1883.
Niagara Falls, N. Y.

1883–1885, Surveys and location of Tunnel for New Croton Aqueduct. 1885–1887, Construction work new Croton Aqueduct and extensive Topographical Survey of the Croton Valley. 1887–1888, In charge of construction as Assistant Engineer at shafts No. 21, No. 22, and No. 23 New Croton Aqueduct (night shift). 1888 to 1891 Assistant Engineer in charge of the construction of two large dams and tunnels connecting the two basins of Double Reservoir "I," located 2 miles east of Brewster, N. Y., on the east Branch of the Croton River. 1891, Special Assistant Engineer Cataract Construction Company.

HUNT, FREDERICK FURNEAUX, E.M., C.E., . . . 1876.
77 Pine Street, New York City. and New Brighton, S. I.

HUNTINGTON, FREDERICK WOLCOTT, E.M., . . . 1885.
Terraceia Phosphate Co., Barstow, Polk Co., Florida.

HURLBUT, ELISHA DENISON, JR., C.E., ... 1890.
106 Hicks Street, Brooklyn, N. Y.

1890–91, at Columbia College Law School. 1891-93, Assistant in Mechanical Engineering, School of Mines.

HUTTON, FREDERICK REMSEN, A.B., A.M., E.M., C.E., PH.D. (Life Member), ... 1876.
Columbia College, and 296 Lexington Avenue, New York City.

1876–1877, Assistant in Engineering, School of Mines. 1877–1882, Instructor in Mechanical Engineering. 1882–1891, Adjunct Professor Mechanical Engineering. 1891, Professor Mechanical Engineering.

I.

IHLSENG, AXEL OLAF, B.S., E.M., C.E., ... 1877.
Carthage, Mo., and 151 East 33d St., New York City.

1877–1882, Chief Chemist, Havemeyer Sugar Refining Co., Brooklyn, E. D. 1882–1890, U. S. Dep. Mining Surveyor, District of Colorado. 1882–1883, Chemist and Assayer, La Plata Smelter, Leadville, Colo. 1883, Metallurgist, Martha Rose Smelter, Silverton, Colo. 1884, Assayer, Stoiber Sampling Works, Silverton, Colo. 1885, Duyckinck, Schuyler & Ihlseng, Ore Samplers, Silverton, Colo. 1886-1890. Manager of Mt. Queen Mining Co, Reliance Mining Co., Brown Mining Co., and the Hale

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Mines, Silverton, Colo. 1890–1892, Operating Zincite Mine and others near Webb City, Nevada, and in constructing concentrating plants.

IHLSENG, MAGNUS C., E.M., C.E., PH.D., . . . 1875.
Professor Engineering, State School of Mines, Golden, Colo.

ILES, MALVERN WELLS, PH.B., PH.D. (Life Member), . 1875.
Superintendent Globe Smelting Co., Denver, Colo.

ILLIG, WILLIAM CHARLES, E.M., ... 1882.
327 E. Forty-first Street, New York City.

INGERSOLL, WILLIAM HALSEY, A.B., A.M., LL.B., E.M., (Life Member), ... 1870.
Northport, Suffolk County, N. Y.

1875–1878, Assistant in Engineering, Columbia College. 1878–1881, Assistant in Mechanics and Astronomy. 1881–1887, Manufacturing tin-ware, Portland, Conn. 1887–date, Incapacitated from practice by lack of health.

J.

JACKSON, OSWALD, C.E., ... 1892.
Principal Assistant Engineer United Railways of New Jersey Division P. R. R., Jersey City, N. J., and 550 Park Ave., N. Y. City.

JACOBS, DAVID MARK, PH.B., ... 1887.
R. J. Jacobs, 41 New St., and 30 W. Thirty-eighth St., N. Y. City.

JACOBS, SOLOMON JOSEPH, PH.B., ... 1887.
R. J. Jacobs, 41 New St., and 30 W. Thirty-eighth St., N. Y. City.

JANEWAY, JOHN HOWELL, E.M., ... 1886.
John A. Roebling's Sons Co., and 124 West State St., Trenton, N. J.

1886, Underground and Surface Surveyor for Cooper, Hewitt & Co. 1887–1891 Draughtsman and Designer and Constructing Engineer of Wire Rope Tramways in Montana, Oregon, Alaska, and California for the Trenton Iron Co., Trenton, N. J.

JENKS, ARTHUR WILTON, E.M., ... 1886.
Supt. Kootenay Lake Reduction Co., Pilot Bay, and care E. E. Olcott, 18 Broadway, New York City.

Summer 1886, New Jersey on Geological Work. 1886–1887, In Cerro de Pasco, Peru, S. A. Assayer and Chemist to the commission examining that silver mining district. Spring, 1887, In New York, Chemist with Ledoux & Co. 1887–1888, In Aurora, Ill., Assistant at the works of the Chicago and Aurora Smelting and Refining Company. Summer and Fall 1888, In Dutch Guiana, S. A., Assayer and Assistant in the examination of gold deposits. Fall 1888 to date, In Aurora, Ills., Assistant Superintendent at the Aurora Works of the Chicago and Aurora Smelting and Refining Co.

JEUP, BERNARD JOHN THEODORE, C.E., ... 1887.
Sanitary Engineer New York Board of Health, 42 Bleecker St., New York City, and 328 De Graw Street, Brooklyn, N. Y.

JOHNSON, ARTHUR GALE, E.M., ... 1885.
Jensen, Utah.

JOHNSON, ELIAS MATTISON, PH.B., ... 1878.
Isaac G. Johnson & Co., Spuyten Duyvil, N. Y.

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JOHNSON, GILBERT HENRY, PH.B., ... 1878.
Isaac G. Johnson & Co., Spuyten Duyvil, N. Y.

JOHNSON, ISAAC BRADLEY, E.M., ... 1879.
Isaac G. Johnson & Co., Spuyten Duyvil, N. Y.

JONES, JOHN ELMER, E.M., ... 1893.
Hazleton, Pa.

JONES, WILLIAM DENISON, PH.B., ... 1888.
Hecker, Jones, Jewell Milling Co., 206 Produce Exchange, N. Y. City, and 62 Clark Street, Brooklyn, N. Y.

JOPLING, REGINALD FURNESS, E.M., ... 1889.
American Wire Co., 842 Wilson Avenue, Cleveland, Ohio.

November, 1889 to February, 1890, Chemist, Otis Steel Co., Ltd. February, 1890–92, Assistant Manager American Wire Co. Vice-president of same, January, 1892.

JOÜET, CAVALIER HARGRAVE, PH.B., ... 1882.
104 John Street, New York City, and Roselle, N. J.

Analytical Chemist with Ledoux & Ricketts, 1882–1875. Analytical Chemist with G. H. Nichols & Co., Acid Manufacturers at Laurel Hill, L. I., from 1885–1888. Work comprising analyses of their various products and a partial supervision of their manufacture. Analytical Chemist from 1888 to present time with Ricketts & Banks.

K.

KARR, CORYDON POWELL, PH.B., ... 1878.
Architect, and Art Editor of *Building*, 23 Warren Street, New York City.

KELLY, WILLIAM, A.B., E.M., ... 1877.
Vulcan, Dickinson Co., Mich.

1877, '79, '80, Assistant Superintendent, Chemical Copper Co., Phœnixville, Pa. 1878, Chemist, Himrod Furnace Co., Youngstown, Ohio. 1881–84, Superintendent, Kemble Coal and Iron Co., Riddlesburg, Pa.; 1885, Superintendent, Glamorgan Iron Co., Lewistown, Pa.; 1886–89, Superintendent, Kemble Iron Co., Riddlesburg, Pa.; In charge of Blast-furnaces, Coal Mines, Coke Ovens, Ore Mines, Quarries, Railroads, etc. 1889 to date, General Superintendent and Gen'l Manager Penn Iron Mining Co., Vulcan, Mich.; In charge of Iron-ore Mines on the Menominee Range, Lake Superior. Also, 1885–89, President Board of Examiners of Bituminous Mine Inspectors of Pennsylvania.

KEMP, JAMES FURMAN, A.B., E.M., ... 1884.
Prof. Geology, Columbia College, School of Mines, New York City.

Several months with the Rand Drill Co., 1883–1884. Private Assistant to Prof. J. S. Newberry, 1884–85. Student of Geology and Mineralogy at the Universities of Leipzig and Munich, Germany, 1885–86. Instructor in Geology at Cornell, 1886–88. Assistant Professor of Geology and Mineralogy, 1888–91, and Secretary of the Faculty, 1888–89. Have travelled in the West in 1889, and for two summers past have been working on the Geology of the Lake Champlain region and Adirondacks. Am especially engaged on Inorganic and Economic Geology. 1891, Adjunct Professor of Geology, School of Mines, Columbia College. Professor, 1892.

KINSEY, FRANK WILMARTH, C.E., ... 1891.
Manager for R. W. Hildreth & Co., 2 Wall St., N. Y. City, and 10 South Street, Newark, N. J.

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Assistant to Engineers' Rapid-Transit Commission, 1891–92. Engineer of Construction East Providence Water Works, 1892. Designing Engineer with S. M. Gray, 1892–93. 1893, Manager for R. W. Hildreth & Co.

KISSAM, HENRY SNYDER, PH.B., ... 1886.

Architect, Psi Upsilon Club, 33 W. Forty-second St., N. Y. City.

1888–89, Manager of Office of Pickles & Sutton, Architects, Tacoma, Washington. 1889–90, Practicing Architecture with P. W. Morris under firm name of Kissam & Morris, Tacoma, Washington. 1890-92, Practicing Architecture alone under name of Henry Snyder Kissam, Tacoma, Washington. 1892, Practicing Architecture with Jno. G. Proctor, under firm name of Proctor & Kissam, Tacoma, Washington. During 1893, in New York City, as Student of Special Construction.

KOCH, EDWARD CABOT, E.M., ... 1879.

Assistant General Manager, Elmore Gold Co., Limited, Rocky Bar, Idaho, and 160 E. Fifty-sixth Street, New York City.

1880, 1881, 1882, Assayer and Chemist at Smelters, Leadville, Colo. 1883–1888, Surveyor and Assistant Superintendent, L. A. G. Mg. Co., Colo. 1889 to date, Assistant General Manager E. G. Co., Ltd., and V. G. Co., Ltd., Idaho.

KOEN, JOSEPH JOHN, C.E., ... 1888.

Board of Health, 301 Mott Street, New York City, and Pearsalls, N. Y.

1889–90, Computer on New Croton Aqueduct. 1890-91, to date, Sanitary Engineer on New York City Board of Health.

KUNHARDT, WHEATON BRADISH, E.M. (Life Member), . 1880.

32 Beaver Street, New York City.

1880–82, Travel and Study in the West and in Europe. 1883–88, Engineer for the Bower-Barff Rustless Iron Co., and Assistant of Geo. W. Maynard in consulting work on Iron-mines and Ore-dressing. 1888–89, First Assistant Engineer of the Boston Heating Co., under A. V. Abbot, as Chief Engineer. 1890-91, Examination and Exploration of Iron and Coal Deposits in New England, with the Diamond Drill. Report on Direct Steel Processes and on Magnetic Separation for Iron-ores. Acting Secretary of the American Institute of Mining Engineers for four months. 1892, President of the Osceola (Gold) Gravel Mining Company.

KURTZ, EDWARD LAURENCE, E.M., ... 1893.

17 Pittsburgh Street, Newcastle, Pa.

L.

LACOMBE, CHARLES FREDERICK, E.M., ... 1885.

The Mountain Electric Co., 1 and 2 Duff Block, 1754 Larimer Street, and 1528 Gilpin Street, Denver, Colo. Also, University Club, New York City.

1885 to 1886, Assayer and Surveyor and Foreman of Lucky Boy and South Galena Mines, in Bingham, Utah. 1886 to 1888, Assistant Instructor in Assaying, and Fellow in Chemistry, School of Mines, Columbia College, N. Y. 1888 to 1890, Examining Gold and Silver Mines in Colorado, Utah, Montana, Arizona and Old Mexico. 1890, Testing Electrical Apparatus in Virginia City, Nevada. 1890, Manager of the Gilpin Co. Light, Heat and Power Co., Central City, Colo. 1890 to date, President and Manager, The Mountain Electric Co. Specialty, Installing Electric Light and Power Stations, and adapting electric light and power for mining purposes.

LAHEY, JOSEPH, E.M., ... 1887.

162 E. Seventy-eighth Street, New York City.

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LAHEY, RICHARD, E.M., ... 1887.
Wilson Bros. & Co., Drexel Building, Philadelphia, and 162 E. Seventy-eighth Street, New York City.

LAMB, ANDREW JOHNSON, E.M., ... 1884.
L. & N. Railway, Louisville, Ky.
June, 1884, to June, 1887, New York Croton Aqueduct, Draughtsman. June, 1887, to Sept., 1890, Assistant Engineer, L. & N. Railroad. Sept., 1890, to June, 1891, Assistant Roadmaster, Knox. Div., L. & N. Railroad.

LANGTHORN, J. S. (Associate), ... 1891.
Union Electric Company, 45 Broadway, N. Y. City, and 196 Joralemon Street, Brooklyn, N. Y.

LAWRENCE, BENJAMIN BOWDEN, E.M., ... 1878.
Hooker & Lawrence, 145 Broadway, and 216 E. Eighteenth Street, New York City.
1878–84, Superintendent, Montezuma S. M. Co., and of other mines of Summit Co., Colo. 1884–91, Lessee and Operator of Mayflower and Pelican-Dives Mines, Clear Creek Co., Colo. In 1886, Formed partnership with W. A. Hooker, E.M., Class of 1869, with office at 145 Broadway, as Consulting Mining Engineers. I make a specialty of operating under lease or otherwise, true fissure Gold and Silver Mines, also Concentration of Gold-silver ores. Address during summer of 1891, Georgetown, Colo., at the Pelican-Dives Mines.

LEARY, DANIEL JAMES, C.E., E.M., ... 1881.
Eagle and Provost Streets, Brooklyn, N. Y., 22 State Street and 43 E. Twenty-fifth Street, New York City.
1882 to date, Constructing Highway and Railroad Bridges, Wharves, Docks, Dredging and Harbor Improvements generally, in vicinity of New York City, as Designing and Supervising Engineer, as well as Contractor in most instances. In general, make a specialty of both Engineering and Constructing work, or Engineering work alone, in this branch of the profession.

LEARY, GEORGE, C.E., ... 1891.
43 E. Twenty-fifth Street, New York City.

LEAVENS, HARRY WENMAN, E.M., ... 1875.
Salt Lake City, Utah.

LEBOUTILLIER, CLEMENT, PH.B., ... 1881.
High Bridge, New Jersey.
1884–7, Assistant Chemist, Cambria Iron Co. 1887–92, Chemist, Eliza Furnace. March, '92, to date, Chemist, Taylor Iron and Steel Company.

LEDERLE, ERNST JOSEPH, PH.B., ... 1886.
Assistant Chemist, New York City Health Dept., 42 Bleecker St., and 120 W. 90th St., New York City.
1886–87, Hon. Fellow Quant. Anal. and Assist. Intr. Gen. Chemistry, School of Mines. 1887–88, Chemist, Cranmoor Farm, Tom's River, N. J. 1888–89, Asst. Chemist, New York City Health Dept. 1890–91. Chemist and Supt., Reed & Carnrick, New York. 1891–92 as above, specialties, food and food preparations.

LEDOUX, ALBERT REID, M.S., PH.D. (Associate), . . 1874.
Ledoux & Co., 9 Cliff Street, New York City.

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LEE, GEORGE BARSTOW, E.M., ... 1885.
Rio Grande Smelting Co., Socorro, New Mexico, and 71 E. Eighty-fourth Street, New York City.

1885, Assayer in Butte, Montana. 1886–1887, Assayer, Kansas City Smelting and Refining Co. 1887 to date, Assistant Superintendent, Rio Grande Smelting Co., Socorro, New Mexico.

LEGGETT, THOMAS HAIGHT, E.M., ... 1879.
Standard Consolidated Mining Co., Bodie, Mono County, Cal., and 310 Pine St., San Francisco, Cal.; also, 18 Broadway, N. Y. City.

1880, Assistant Engineer, New York River and Harbor Surveys. 1881–1883, Superintendent of Mining Properties in the Batopilas District, Chihuahua, Mexico. 1884, Travelling in the West, through the principal Mining Camps, Butte, Leadville, etc. 1884–1887, Mining Engineer to the New York and Honduras Rosario Mining Co., at San Juancito, Honduras. 1888, Manager of Mudsill Mining Co., Fairplay, Colo.; office, 23 Bucklersbury, London, E. C. 1889–1890, General Manager, Darien Gold Mining Co., Ltd., of Cana, Rep. of Colombia, and 86 King St., Manchester, England. 1891–93, President and Manager Standard Consolidated Mining Co.

LENOX, LIONEL REMOND, PH.B., ... 1888.
Assistant Professor Chemistry, Leland Stanford, Jr., University, Palo Alto, California.

After three years' work in the School of Mines, and previous to my senior year, I was respectively in: 1887, three months Assistant Chemist to Fulton Sugar Refinery. 1887, six months Assistant Chemist to Bethlehem Iron Co. 1888–89, Instructor in Qualitative Analysis and Assaying, Lehigh University. 1889–91, Instructor in Quantitative Analysis and Industrial Chemistry, Lehigh University. 1892–93, Chemist, Bureau of Ordnance, Washington, D. C.

LEVY, ALBERT LINCOLN, E.M., ... 1890.
Fischel & Levy, Hartford, Conn.

LIEBMANN, ALFRED, C.E., ... 1893.
28 East Seventy-second Street, New York City.

LILLIENDAHL, ALFRED WHIPPLE, E.M., ... 1883.
Superintendent, Mazapil Copper Co. (Ltd.), Concepcion del Oro, Estado de Zacatecas, Mexico and 82 Danforth Avenue, Jersey City, N. J.

1883–85, Assistant Supt. Aurora Smelting and Refining Co., Aurora, Ill. 1885–87, Assistant Supt. Grande Milling and Refining Co., Guanajuato, Mexico. 1888–93, Superintendent of the Mazapil Copper Co., Ltd., Concepcion del Oro, Zacatecas, Mexico.

LILLIENDAHL, FRANK ARMSTRONG, E.M., . . . 1891.
Assistant Superintendent and Metallurgist, Mazapil Copper Co. (Sta.), Concepcion del Oro, Estado de Zacatecas, Mexico, (via Laredo, via Saltillo), and 82 Danforth Avenue, JerseyCity, N. J.

1891–93, as above.

LILIENTHAL, JOHN LEO, E.M. (Life Member), . . 1870.
1918 Jackson Street, San Francisco, Cal.

1871, Assistant in Laboratory, Prof. Chandler, School of Mines. Assistant in Field Work, Prof. Newberry, Ohio Geological Survey. Assistant in Lecture Room, Prof. Joy, Columbia College. Assistant in Metallurgical Laboratory, Prof. Egleston, School of Mines. 1872–1891, Mercantile Business, San Francisco.

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LILLIE, SAMUEL MORRIS, E.M., ... 1874.
328 Chestnut Street, Philadelphia, Pa.
1874–75, Chemist, Kings County Refining Co., Green Point, L. I. 1876–85, Chemist, Franklin Sugar Refinery, Philadelphia, Pa. 1886–1887, Sugar Engineer and Chemist. 1888, 1889 and 1890, Vice-President and Manager of "The Sugar Apparatus Manufacturing Co.," a Company organized under the Laws of Pennsylvania, to operate under his patents. 1891, President of said Company.

LIPPS, HENRY, JR., C.E., ... 1888.
R. & D. R.R., Box 14, Greensboro, N. C.
From July, 1888, to August, 1889, Assistant Engineer Maint. of Way, Dep. R. & D. R.R., W. N. C. & Va. Mid. Div. August, 1889, to January, 1890, Supervisor Track, N. C. Div. R. & D. R.R. January, 1890, to date. Engineer Maint. of Way, N. C. Div. R. & D. R.R.

LITTLE, WILLARD PARKER, E.M., PH.B., . . . 1881.
Architect, 28 West Twenty-Third Street, New York City.

LIVINGSTON, ARCHIBALD ROGERS, C.E., ... 1891.
333 Munroe Ave., Scranton, Pa., and 20 North Washington Square, New York City.
Since November, 1891, in employ of Lackawanna I. & S. Co., Scranton, Pa.

LONGACRE, LINDSAY B., M.E., ... 1892.
Spuyten Duyvil, N. Y.

LORD, FREDERICK REUBEN, C.E., ... 1892.
——— ———, Staten Island, N. Y.

LOVE, EDWARD GURLEY, A.M., PH.B., PH.D., . . 1876.
Gas Examiner, Department Public Works, and 69 East Fifty-fourth Street, New York City.

LUDLOW, EDWIN, E.M., ... 1879.
Superintendent Choctaw Coal and Railway Company, Hartshorn, Indian Territory.
1879–81, Assistant Engineer in charge of hydrographic work on Delaware River, under U. S. Engineer. 1881, Assistant Engineer Mexican National Railroad, Mexico. 1882–89, Assistant Superintendent, then Superintendent, for Pennsylvania Railroad coal-mines at Shamokin, Pa. 1889 to date, Superintendent of Mines, Choctaw Coal and Railroad Company, Hartshorn, Indian Territory.

LUQUER, LEA MCILVAINE, C.E., ... 1887.
Tutor in Mineralogy, School of Mines, N. Y. City, and Bedford, N. Y.
Summer of 1887, Assistant in Geodetic Surveying with Professor Rees. Summer of 1887, Assistant in Surveying with Professor Monroe. Summer of 1888, Assistant in Geodetic Surveying with Professor Rees. 1887–90, Fellow in Mineralogy, School of Mines. 1890, Assistant in Mineralogy, School of Mines. 1891 to date, Tutor in Mineralogy, School of Mines.

LUQUER, THATCHER TAYLOR PAYNE, C.E., E.E. (1892), . 1889.
45 Broadway, N. Y. City, and 618 Henry St., Brooklyn, N. Y.
1890, Fellow in Engineering. 1890–91, Fellow in Surveying and Practical Mining. 1891, Assistant in Mining, Columbia College, School of Mines. 1892, with H. Ward Leonard & Co., New York City. 1893, Engineer, Union Electric Co., N. Y. City.

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LUSK, GRAHAM, PH.B., PH.D. (Munich, 1891), . . 1887.
Assistant Professor of Physiology at the Yale Medical School, New Haven, Conn. Address: 47 East Thirty-fourth Street, N. Y.

1887–1888, Student at Munich. 1889, Student at Munich; also at Bellevue Hospital Medical College, N. Y. 1890, Studied at Bellevue; afterwards in Munich. 1891, Studied at Munich; and was later appointed Instructor of Physiology at the Yale Medical School. 1892, Assistant Professor of Physiology.

LUTTGEN, EBERHARD, PH.B., ... 1884.
Wissahickon Chemical Works, Ambler and Chelten Hills, Wyncote P.O., Pa.

1884–85, Assistant Chemist, Crane Iron Company, Catasauqua, Pa. 1885 to date, Chemist and Manager, Keasbey & Mattison's Chemical Works, Ambler, Pa. Specialty, manufacture of magnesia.

LYMAN, FRANK, A.B., M.E., ... 1878.
31 Burling Slip, New York City, and 50 Remsen St, Brooklyn, N. Y.

M.

MCCULLOH, EDWIN AUSTIN, PH.B., ... 1878.
Glencoe, Md.

MCKENNA, CHARLES FRANCIS, PH.B., ... 1883.
J. J. McKenna & Bros., Brass Founders, 424, 426 East Twenty-third Street, and 144 West Ninety-ninth Street, New York City.

1883–84, Chemist Havemeyer Sugar Refining Company, Jersey City, N. J. 1885–86, Chemist Cambria Company, Johnstown, Pa. 1887–90, Chemist Edgewater Lime Works, Edgewater, N. J. 1890, Chemist Jas. J. McKenna & Bros., Brass Founders, 424, 426 East Twenty-third Street, New York City.

MCKIM, ROBERT ALBERT, C.E., ... 1884.
Room 213, 280 Broadway, and 9 East Tenth St., New York City.

Assistant Engineer on New Croton Aqueduct. (Entered Aqueduct Engineer Corps as Chainman, in February, 1885.)

MCLAUGHLIN, CHARLES SWAIN, PH.B., ... 1884.
874 Broadway and 2041 Fifth Avenue, New York City.

MACKAYE, HAROLD STEELE, C.E., ... 1887.
Westinghouse Electric Mfg. Co., Pittsburgh, Pa.

Three months' work in New York Harbor in Army Corps of Engineers. One year's employment in the Office of Patent Solicitors. 1889–92, acting as Fourth Assistant Examiner of the U. S. Patent Office.

MACTEAGUE, JOHN JOSEPH, E.M., ... 1883.
Mexican Ore Company, El Paso, Texas.

MACLAY, JAMES, C.E., ... 1888.
Tutor in Mathematics, Columbia College, and 87 Union Street, Newark, N. J.

MAHONY, ARTHUR STUART, E.M., ... 1889.
51 West Ninety-fourth Street, New York City.

1890, First Assistant General Manager of the New Birmingham Iron and Land Company. 1891, Treasurer of the same company, also Chemist to the Tassie Belle Furnace, New Birmingham, Texas.

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MANNHEIM, HERMANN CHARLES, E.M., ... 1887.
St. Louis Smelting and Refining Company, Howard Station, St. Louis, Mo., and 76 Warren Street, New York City.

MANNHEIM, PAUL AUGUST LOUIS, E.M., ... 1885.
United Smelting and Refining Company, East Helena, Montana.

MARIÉ, LEON, E.M., ... 1885.
12 East Forty-sixth Street, New York City.

MARSH, JOHN ROLLIN, E.M., ... 1887.
Chief Engineer Indiana Bridge Co., and 616 E. Adams St., Muncie, Ind.
August 1, 1887, to date, as above.

MARTIN, EDWARD WARD (Associate), ... 1877.
Chemist, Board of Health, 301 Mott Street, New York City.

MASSA, CHARLES GRISWOLD, C.E., ... 1889.
Chief-Engineer's Office, P. R.R., Pa. Ave., Pittsburgh, Pa., and Fort Lee, N. J.
Oct. 1889 to date, on railroad and street railway construction, and miscellaneous works.

MASSA, LOUIS FERDINAND, C.E., ... 1890.
School of Mines, New York City, and Fort Lee, N. J.
October, 1890, to 1892, shop practice, Maryland Steel Works, at Sparrow's Point, Md., as follows: October, 1890, to July, 1891, Machine-shop practice. July, 1891, to Sept., 1891, Bessemer-mill Construction. Sept., 1891, to Sept., 1892, Bessemer Rail-mill and Roll-house; Mechanical and Metallurgical Engineering. October, 1892, to date, Post-graduate Electrical Eng. at Columbia College.

MATHIS, THEOPHILUS SMITH, E.M., ... 1879.
Engineer of Mines, and U. S. Surveyor General's Office, and 529 East St., Salt Lake City, Utah.
From January, 1890, to February, 1891, Assistant Draughtsman U. S. Surveyor General's Office, Salt Lake City, Utah. Since Feb., 1891, Chief Draughtsman of Mineral Division of said Office, and still holds that position.

MAYER, RALPH EDWARD, C.E., ... 1879.
Instructor in Mechanical Drawing, School of Mines, Columbia College, New York City.

MEISSNER, CARL AUGUST, PH.B., ... 1880.
Vanderbilt Steel and Iron Company, Box 867, Birmingham, Ala.
One year, Assistant Chemist Joliet Steel Company. Three years, Chemist and Assistant Superintendent Brier Hill Iron and Coal Company, Youngstown, Ohio. One and a half years, Head Chemist Joliet Steel Company. Three years, Manager Sterling Iron and R'wy Company, Sterlington, N. Y. At present, Vice President and General Manager of the Vanderbilt Steel and Iron Company, Birmingham, Ala., after having personally organized this company.

MELLISS, D. ERNEST, A.M., PH.D. (Associate), . . . 1868.
Price's Building, 524 Sacramento Street, San Francisco, Cal.
Student regular course, three years, School of Mines. Afterwards, two and a half years University of Goettingen, graduating Ph.D., in 1869. One year at University of Vienna. Since then, constantly occupied in civil and mining engineering. In 1873, was Chief Engineer in charge of Topographical and Geological Survey of Guano-

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caste and Nicoya for the Costa Rican Government. In 1881, Consulting Engineer to the Pacific Gas Light Company, of San Francisco, and in its interest studied the different gas-making systems in the United States, England, France and Belgium. Have made plans for and erected numerous gold, silver, copper and lead mines. Planned the Union Iron Works of San Francisco, and superintended their construction; also the Arctic Oil Works and several other industrial establishments on the Pacific Coast. Designed and built the Mazatlán Water Works in Mexico; the Hydraulic Press Brick Works, of California, the largest establishment of its class on the Pacific Coast. Four years in Central America and Mexico. Was Administrator of San José de las Bocas and Consulting Engineer to Guadalupe de los Reyes, the most successful silver mine of Sinaloa. Am now Consulting Engineer in San Francisco.

MERRILL, FREDERICK JAMES HAMILTON, PH.B., PH.D., . 1885.
State Museum, and 2 Sprague Place, Albany, N. Y.

1885–87, Assistant on the Geological Survey of New Jersey. 1886–90, Fellow in Geology, Columbia College. 1890 to date, Assistant State Geologist and Assistant Director of the New York State Museum, Albany, N. Y.

MERRITT, JAMES HAVILAND, PH.B., A.M., . . . 1880.
Columbia Col., School of Mines, and 3 Monroe Place, Brooklyn, N. Y.

From 1881–1888, Chemist to the Bradley White Lead Co. In 1889, entered the School of Mines as Post Graduate in the course of Architecture. 1892–93, Architectural Study.

MERWIN, HUBERT JOHN, E.M., ... 1879.
Care Chas. Seymour, Knoxville, Tenn.

MERZ, EUGENE, M.E., ... 1892.
Box 216, and 143 Littleton Ave., Newark, N. J.

MESEROLE, WALTER MONFORT, C.E., ... 1881.
Engineer, Atlantic and Van Siclen Avenues, Brooklyn, N. Y.

1881, Transitman and Topographer Continental Railway Co. 1881–83, Assist. Eng. in Construction N. Y., West Shore and Buffalo Ry. 1884–85, Division Engin'r Maintenance of Way; 1885, Chief Engineer Catskill Mtn. and Cairo Railway. 1885, in charge Topographical Survey for Kings County Charities' Commission. 1886 to date, in General Practice, located at Brooklyn, N. Y. Specialties: Improvement and Development of Real Estate and Surveying for Legal and Construction Purposes; City Surveyor of the City of Brooklyn; Chief Engineer South Brooklyn R. R. and Terminal Company, German-American Improvement Co., and Hancock and State Line Railway Company.

MEYER, HERMAN HENRY BERNARD, E.M., . . . 1885.
539 W. Twentieth Street, New York City, and 162 Heywood Street, Brooklyn, N. Y.

Surveying, Field and Office work at Pelham Park, Westchester Co., July to November, 1885. December, 1885 to date, Engineer for Oregon Iron Works, New York; designing and erecting machinery for manufacturing illuminating gas.

MIDDLETON, JOHN, C.E., ... 1887.
350 Clermont Avenue, Brooklyn, N. Y.

MILLER, CHARLES LEWIS, E.M., ... 1885.
Illinois Steel Company, 3179 Ashland Avenue, and 3609 Ellis Avenue, Chicago, Ill.

1886, Assistant Chemist Edgar Thomson Steel Works, Braddock, Pa. 1886–87, Chemist and Assistant Supt. Carbon Iron and Pipe Co., Perryville, Pa. 1887–90, Supt.

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The Missouri Furnace Co., St. Louis, Mo. 1890 to date, Supt. Blast Furnace at Union Works of Illinois Steel Co., Chicago, Ill.

MILLER, CHARLES WATTS, E.M., ... 1884.
Box, 401, Aspen, Colo.

1884–1885. Metallurgical Engineer Hecla Bronze and Iron Works. 1885–1886, Assayer and Chemist, Aspen, Colo. 1886–1891, Mining Engineer and United State Deputy Mineral Surveyor, Aspen, Colo. General mining engineering business.

MILLER, EDMUND HOWD, PH.B., A.M. (1892),. . . 1891.
Assistant in Assaying, Columbia College School of Mines, and West Nyack, N. Y.

1892–93, as above.

MILLER, RUDOLPH PHILIP, C.E., ... 1888.
Box 355, Richmond, Va.

1888–1890, Assistant to E. M. W., 1890 to date, Supervisor R. and D. Railway.

MILLIKEN, GEORGE FANSHAWE, E.M., ... 1879.
Land Department, N. P. R. R., Tacoma, Wash., and Union League Club, New York City.

1879–1880, Superintendent "Milton Mining Company." 1880–1883, General Manager "Chester Mining Company." 1883–1887, In General Consulting Practice as Engineer. 1887–1890, General Manager "Costa Rica Mining Co., Ltd." 1890 to date, Consulting Engineer Northern Pacific Railroad.

MOFFATT, EDWARD STEWART, A.B., A.M., E.M., . . 1868.
President and General Manager Lackawanna I. & S. Co., and 306 Quincy Ave., Scranton, Pa.

For a month or so during Summer of 1868 worked at Blast Furnaces of Bethlehem Iron Co. During sessions of 1868–1869 and 1869–1870 was Adjunct Professor of Mining and Metallurgy at Lafayette College, Easton, Pa. From 1870–1872, Engaged in Engineering and Metallurgical Work in Northern New Jersey. From 1872–1876, was Manager of Port Oram Blast Furnace, New Jersey. From 1876–1878, Superintending Construction of Secaucus Blast Furnace. From 1878–1882, was Manager of the Blast Furnace and Mines of the Musconetcong Iron Co. 1882–1886, Superintendent of Blast Furnaces and Assistant General Manager Lackawanna Iron and Coal Co. 1886–1891, General Manager Lackawanna Iron and Coal Co. From January 1, 1891, General Manager Lackawanna Iron and Steel Co., the new company which has been formed by consolidation of Lackawanna Iron and Coal Co. and Scranton Steel Co. October, 1892, to date, as above.

MOLDEHNKE, RICHARD GEORGE GOTTLOB, E.M., PH.D.,. 1885.
McConway & Torley Co., Forty-eighth Street and A. V. R.R., and 164 Home Street, Pittsburgh, Pa.

1885, '86, '87, Three Summer seasons with United States Coast and Geodetic Survey, New York and Philadelphia Harbors and Cape Cod, Mass., *Hydrographic Work*, Triangulation, Levelling, etc. 1885–1886, Winter, nine months, *Sanitary Engineering*, Inspector, etc., New York Association for Improvement of Condition of Poor. 1887–1889, *Electrical Engineering*, five months Mining Engineer Sprague Electric Railway and Motor Co., seven months Mechanical Engineer Crocker-Wheeler Motor Co., five months experimenting on patents taken out. 1889, Manufacturing for myself. Specialty in Machinists' Tools. 1889–1890, Professor Mechanical and Electrical Engineering Michigan Mining School, Houghton, Mich. 1890 to date, Engineer McConway & Torley Co. (Manufacturers Janney Coupler, M. C. B. type). In addition to regular Engineering Work of Manufacturing Plant, conducting Metallurgical Investigations

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in line of Malleablization of Cast-iron. Specialties: Malleablized Cast-iron and Oil Fuel Gas.

MONELL, JOSEPH THOMPSON, C.E., ... 1889.
Columbia College, and 236 W. Twenty-second Street, New York City.
1891, Electrical Engineering, Curtis Electrical Mfg. Co. 1892 to date, Tutor in Astronomy, Columbia College.

MONTENEGRO, MANUEL RAFAEL, E.M, ... 1890.
35 Broadway, New York City.

MORA, MARIANO LUIS, C.E., ... 1891.
Columbia College, School of Mines, New York City.

MORAN, DANIEL EDWARD, C.E., ... 1884.
Sooysmith & Co., 2 Nassau Street, and 26 W. Eighteenth Street, New York City.

MORGAN, LANCASTER, PH.B., ... 1888.
Hudson River Chemical Works, 47 Fulton St., and 68 Madison Ave., New York City.

MORGAN, WILLIAM FELLOWES, A.B., E.M. (Life Member), 1884.
Brooklyn Bridge Freezing and Storage Co., Arch 4 Brooklyn Bridge, New York City, and Short Hills, N. J.
1884–1888, Banking and Brokerage. 1888 to date, as above.

MORRIS, GOUVERNEUR WILLIAM, E.M., ... 1878.
Meyers, Rutherford & Co., 58 Wall Street, and 123 W. Thirty-fourth Street, New York City.
Banker and Broker.

MOSLEY, RICHARD KEELER, PH.B., ... 1889.
Architect, 19 W. Twenty-fourth St., N. Y. City, and 139 Glenwood Avenue, East Orange, N. J.
From June, 1889, to January, 1893, worked as Draughtsman in the Offices of S. J. O'Conner, Carrère & Hastings, and Richard M. Hunt, of New York, and Benj. Silliman, of Yonkers, N. Y. Since January, 1893, practicing Architecture independently at the above address.

MOSES, ALFRED JOSEPH, E.M., PH.D., ... 1882.
Adj. Professor Mineralogy, Columbia College School of Mines, New York City.
1882–1885, Assistant in Mineralogy, School of Mines. 1885–1890, Instructor in Mineralogy and Metallurgy. 1890 to date, Adjunct Professor of Mineralogy. Managing Editor SCHOOL OF MINES QUARTERLY.

MULFORD, ROBERT, E.M., ... 1884.
Mt. Vernon, N. Y.
1890, Assistant Superintendent Rio del Oro Gold Co., Argentine Republic, S. A. 1891, Honduras?

MÜLLER, GEORGE, PH.B., ... 1887.
Chemist, care Puget Sound Reduction Co., Everett, Washington.

MUNOZ DEL MONTE, ADOLPHO CARLOS, C.E., PH.B., . 1888.
Chestnut Hill, Philadelphia, Pa.
Returned from Europe, November, 1892, where, from June, 1891, travelled as a "McKim Fellow in Architecture."

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MUNROE, HENRY SMITH, E.M., PH.D., ... 1869.
Professor Mining, Columbia College School of Mines, and 45 Sidney Place, Brooklyn, N. Y.

1869–1870, Post Graduate student in Chemistry and Economic Geology, School of Mines. 1870–1871, Assistant Geologist Ohio State Geological Survey. 1870–1872, Assistant Chemist, Department of Agriculture, Washington, D. C. 1872–1875, Assistant Geologist and Mining Engineer, Geological Survey of Yeddo, Japan. 1875–1876, Professor of Geology and Mining, University of Tokio, Japan. 1877–1891, Adjunct Professor of Surveying and Practical Mining, and 1891, Professor of Mining, School of Mines Columbia College, New York City. Specialties, Economic Geology, Ore Dressing, and Mining Engineering.

MUNROE, OTIS MORTIMER, PH.B., ... 1879.
Banker, De Soto, Mo.

MUNSELL, CHARLES EDWARD, PH.B., PH.D., . . . 1878.
Assistant Chemist, F. W. DeVoe & Co., 100 Horatio Street, New York City, and Rye, N. Y.

November, 1868, with A. E. Foote, Mineral Dealer, Philadelphia. March, 1879, with T. A. Edison, Menlo Park, N. J. May, 1879, Chemist, Bushwick Chemical Works, Brooklyn, N. Y. October, 1879, Stencilographer and Celestyper, School of Mines, N. Y. January, 1880 to December, 1885, Milk Inspector, New York City Health Department. July, 1881 to May, 1883, State Milk Inspector, New York State Board of Health. January, 1886 to date, Analyst and Assistant Chemist, F. W. Devoe & Co., and C. T. Reynolds Co., New York City. Specialty, Paints and Colors.

MURPHY, HENRY MORGAN, E.M., ... 1878.
Murphy Varnish Co., Chestnut and McWhorter Streets, Newark, N. J.

MURPHY, JOHN GLENVILLE, E.M., C.E., ... 1877.
Times Building, New York City.

Assistant Superintendent Orinoco Exploring and Mining Co., Gold Mine. Assistant Superintendent Callao Gold Mining Co. Territorial Geologist of Wyoming. Superintendent Esmeralda Mining Co., Black Hills, Dakota, Gold Mine. Superintendent New York and Lee Mountain Syndicate, Montana, Lead-Silver Mines. Has made professional examinations in nearly all parts of the United States, the Pachuca Silver and Jugnann Copper Districts in Mexico, and two and half years ago made a six months' trip in Colombia and Ecuador.

N.

NAPIER, ARTHUR HOWELL, E.M., ... 1884.
Sanitary Engineer, Lincoln Bldg., 1 Union Square, West, New York City, and 179 Harrison Street, Brooklyn, N. Y.

1884, Sanitary Engineer and Inspector for New York State "Tenement House Commission" and New York "Society for Improving Condition of Poor." 1885–1889, "Assistant Sanitary Engineer," New York Health Department. 1889 to date, Practicing as Sanitary Engineer, New York City.

NAVARRO, JUAN ADALBERTO, C.E., ... 1880.
Hacienda de San Cristobel Acambara, Estado de Guanajuato, Mexico, and care Mexican Consul General, 35 Broadway, New York City.

1881–1882, Civil Engineering Course in Polytechnicum, Hanover, Germany. 1882–1884, Mexican Government Commissioner to study railway systems of Europe. 1885–1886, Railroad Inspector in Interoceanic Railroad, Mexico. 1886–1887, Assistant

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Compiler of Memoir published by Department of Public Works (*Fomento*), Mexico. 1887 to date, Engineer in charge of Surveys and Representative in Chiopas of the Mexican Land and Colonization Co.

NEFTEL, KNIGHT, C.E., PH.D., ... 1879.
115 Broadway, New York City.

NESMITH, JAMES, E.M., ... 1879.
256 Henry Street, Brooklyn, N. Y.

NETTRE, LIONEL ROBERT, E.M., ... 1869.
Address unknown.

NEWBERRY, SPENCER BAIRD, E.M., PH.D., . . . 1878.
Professor Chemistry Cornell University, Ithaca, N. Y.

NEWBERRY, WOLCOTT ELY, E.M., ... 1884.
Colorado Springs, Colorado.

1885–1885, Metallurgist, Casa Grande Co., Arizona. 1885–1886, Assistant Superintendent Cananea Mg. Co., Sonora, Mexico. 1886–1887, Superintendent Argentum Mining Co., Aspen, Colo. 1887, General Manager Aspen Mg. and Smelting Co., Aspen, Colo. 1888 to present time, General Manager Enterprise Mg. Co., Aspen, Colo. Superintendent Aspen Contract Mg. Co., Aspen, Colo. Superintendent Mutual Benefit Mining and Milling Co., Aspen, Colo. 1892, General Manager Isabella Gold Mining Company, Cripple Creek, Colorado. 1893, as above.

NEWBROUGH, WILLIAM, A.B., E.M., ... 1884.
128 W. Thirty-fourth Street, New York City.

NEWHOUSE, EDGAR LIEBER, E.M., ... 1886.
75 and 77 Worth Street, New York City.

NOBLE, LOUIS SPENCER, E.M., ... 1885.
76 W. Ninetieth Street, New York City, and Leadville, Col.

1885–1889, Mining Engineer to Iron-Silver Mg. Co., and Nisi Prius Cons. Mg. Co., of Leadville, Colo. Also during 1889 Consulting, Reporting and Law-suit work on other Colorado properties. 1889–1890, Superintendent of Mines and Mining Engineer to Constancia Mining and Smelting Co., at Sierra Mojada, Coahuila, Mexico. 1890–1891, Mining Engineer on Law-suit preparation, with Blue Bird Mining Co., Ltd., of Butte, Montana. Specialty, Lead, Silver and Gold Mines and Mining.

NOLAN, THOMAS, M.S., PH.B., ... 1884.
Architect, 503 Wilder Building, Rochester, New York.

NORRIS, DUDLEY HIRAM, E.M., ... 1877.
Address unknown.

NORRIS, ROBERT VAN ARSDALE, E.M., ... 1885.
Assistant Engineer, P. R. R., Dept. of Anthracite Coal, First National Bank Building, and 7 S. Franklin Street, Wilkesbarre, Pa.

1885, Assistant in Practical Mining and Surveying, School of Mines. U. S. Inspector of Dredging, in charge of Maurice River Improvement, Millville, N. J. 1886, Chemist, Herman Behr, Manufacturer of Colors, Brooklyn, N. Y. June, 1886, to date, Assistant Engineer, Pennsylvania Railroad, Department of Anthracite Coal Collieries. Specialty, Mechanical Engineering of Collieries.

NORTON, LUCIEN HOLLEY, E.M., ... 1886.
Mingo Smelting Co., Sandy, Utah, and 123 Fairfield Avenue, Bridgeport, Conn.

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1887–1890, Engineering Office, N. Y., N. H. & W. R. R. Experience in Railroad Construction, Location and Preliminary Surveys, Office Work and General Surveying. 1890, Assayer and Engineer to West Indian New Gold Mining Corporation, San Domingo, West Indies. Experience in Free Melting of Gold-ores, Assaying, Surveying, etc. January, 1891-92, Assayer for Daly Mining Co., Park City, Utah. Experience in Assaying, General Analyses. Also Leaching of Silver-ores by the Russell Process. 1892 to date, as above.

NOYES, JAMES ATKINS, PH.B., A. B. (HARVARD, '83), (Life Member), ... 1878.
74 Sparks St., Cambridge, Mass.

NOYES, WILLIAM SKAATS, E.M., ... 1875
Shafter, Presidio County, Texas.

1877–1879, Assayer for McCrackin Mining Co., Mohave Co., Arizona. 1879–1881, Foreman of Bodie Mill, for Bodie Coal Mining Co., Bodie, Cal. 1881–1883, Examining Mines for San Francisco Capitalists. 1883 to present time, Superintendent of Presidio Mining Co., and The Cibilo Creek Mill and Mining Co., Shafter, Presidio Co., Texas.

NYE, ALVAN CROCKER, PH.B , ... 1884.
Hayden Furn. Co., 1 West Thirty-fourth St., and 107 E. Seventieth Street, New York City.

1884–85, Draughtsman, C. C. Haight, Architect, New York City. 1885–90, Designer and Head Draughtsman, Herter Brothers, New York City. 1890 to date, Furniture Designer and Architect, The Tiffany Glass Co., New York City. 1892, Chief Designer as above.

O.

O'CONNOR, MICHAEL JOSEPH, E.M., PH.B., . . . 1881.
Architect (1884), 28 W. Twenty-third Street, New York City.

O'CONNOR, THOMAS DEVLIN, PH.B., ... 1881.
O'Connor & Elliott, 16 Exchange Place, and 12 E. Forty-fourth Street, New York City.

OLCOTT, EBEN ERSKINE, E.M., ... 1874.
Mining and Metallurgical Engineer, 18 Broadway, and 38 W. Thirty-ninth Street, New York City.

1874–75, Chemist to the Ore-Knob Copper Co., in charge of Hunt & Douglass Process. 1875–76, Assistant Supt Penna. Lead Co.'s Works, Mansfield Valley, Pa. 1876–78, Assistant Supt. Orinoco Exploring and Mining Co., at their Gold Mines in Venezuela. 1878–79, Supt. of the same. 1879–81, Examining Mines in Colorado, Utah, Nevada and California, for New York Investors. 1881–85, Supt. St. Helena Gold Mines, Sonora, Mexico. 1885, opened office in New York as Consulting Engineer, and since then has been engaged as Consulting Mining and Metallurgical Engineer, in Peru, Republic of Colombia, Dutch and British Guiana, Mexico, British Columbia, Ontario, New Brunswick, and the United States.

OOTHOUT, EDWARD AUSTIN, E.M., ... 1882.
41 Liberty Street, New York City.

ORMSBEE, JAMES JACKSON, E.M., ... 1886.
The Sequachee Valley Coal and Coke Co., Pikeville, Bledsoe County Tennessee.

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1886–91, Mining Engineer at Tracy City Mines, of Tennessee, Coal, Iron and Railroad Co. 1891 to date, Superintendent, Thomas Coal Mines, of Tennessee Coal, Iron and Railroad Co., Whitwell, Tenn.

OSTERHELD, THEODORE W., E.M., ... 1886.
Franklin, Pendleton Co., West Va., and Yonkers, N. Y.

Assistant Superintendent of Blast-furnaces, P. S. Co., 1886–87. General Foundry Practice, Worthington P. Works, 1887–88. Owner of Foundry and General Iron Works, 1888–89. Vice-President, Pendleton Mining Co., and Consulting Engineer, 1889, '90, '91, and General Consulting Engineer, Iron and Coal Specialty, and Metallurgist of Iron and Finished Manufacturing. Interval of 1880–91, of the months December to May, Superintending Construction of Rolling Mill, Southwest Virginia. Specialty, Coal and Iron of the Virginias. President of the Southern Reducing Co., Experts, Chemists and Mining Engineers.

OWEN, FREDERICK NASH, E.M., ... 1878.
Civil and Sanitary Engineer, 58 W. Ninety-first Street, New York City.

P.

PAGE, GEORGE STEPHEN, E.M., ... 1885.
Black Diamond Steel Works, Park Bros., Pittsburgh, Pa.

PAGE, WILLIAM STEVENS, E.M., ... 1882.
Aqueduct Commissioner, Sing Sing N. Y.

PAINTER, CHARLES ALBERT, E.M., ... 1884.
J. Painter & Sons, Pittsburgh, Pa.

PAINTER, GEORGE EDWARDS, PH.B., ... 1883.
P. O. Box, 1458, Pittsburgh, Pa.

PARKER, ANDREW MCCLEAN, E.M., ... 1880.
Assistant Engineer, Dept. of Docks, Pier A, New York City.

PARKER, HERSCHEL CLIFFORD, PH.B., ... 1890.
Dept. of Physics, Columbia College, New York City, and 21 Ft. Greene Place, Brooklyn, N. Y.

1890–91, Fellow in Physics, Assistant Instructor, Course in Physical Measurements. 1891–93, Assistant.

PARKER, RICHARD ALEXANDER, C.E., ... 1878.
East Ohio Street, Marquette, Mich.

1878–79. Assistant Superintendent, Montezuma Silver Mining Co., Montezuma, Colo. 1880–81, Surveyor at Georgetown. 1881–82, Chief Draughtsman, Mexican Natl. Cons. Co., Laredo, Texas. 1883–84, Examining Mines in Colorado, Utah and Idaho mainly 1885–86, Superintendent, Atlanta Hill Gold Co. Also Superintendent of the Big Lode (Gold) Co., Atlanta, Alturas Co., Idaho. 1887 to date, Resident Manager and Agent for Samson Iron Co., Imperial Iron Co., and Barasa Iron Co. Also Consulting Mining Engineer. Specialties, Gold and Silver Mining and Milling, and Iron-ores.

PARKS, JOHN RANDOLPH, E.M., ... 1880.
Helena, Mont.

Consulting Mining Engineer.

PARRAGA, CHARLES FREDERICK, C.E. (Life Member), . 1883.
58 William Street, and 145 W. Ninety-seventh Street, New York City.

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1883-84, Inspector of Construction of Bridges and Railroad Material in Europe. 1884-86, Railroad Engineer in Colombia, S. A. 1887 to date, General Expert Business. 1891, Delegate from Colombia to the Inter-Continental Railway Commission at Washington, D. C.

PARROT, EDWARD MOORE, E.M., ... 1870.
Ontario, Wayne County, N. Y.

PARSONS, GEORGE HOWLAND, E.M., ... 1868.
Colorado Springs, Colo.

1870 to 1880, In Nursery Business at Flushing, L. I. 1880 to present time, Secretary and General Manager of the The Colorado Springs Co., and of The National Land and Improvement Co., of Colorado, with Central Office in Colorado Springs. Experienced in the development, improvement and sale of lands in Colorado, especially in and around Colorado Springs, Manitou and Pueblo, also in irrigation works and growth of trees in Rocky Mountain region. Specialty, Investments in Real Estate, Mortgages and Mines in Colorado.

PARSONS, HENRY, C.E., ... 1888.
Vice-president City and Suburban Ry., Savannah, Ga., and 1033 Madison Avenue, New York City.

PARSONS, WILLIAM BARCLAY, A.B., C.E., . . . 1882.
22 William Street, and 51 East Fifty-third Street. New York City.

1881, Engineer on location Amst. and Pine Creek Railroad. Engineer Blossburg Coal Company. 1882, entered service Erie Railway, Maintenance of Way Department. 1885, resigned from Erie and commenced practice in New York as consulting engineer, with railways and water works as specialties. Have been connected since then with following works (among others) as Chief or Consulting Engineer: Fort Worth and Rio Grande Railway, Seneca and Scranton Railway, Amst. and Pine Railway, Sandusky, Ashland and Ashorta Railway, St. Louis, Alton and Springfield Railroad, Louisiana, Arkansas and Missouri Railroad; Stevens Point, Vicksburg, Corry, Kent, Pine Bluff, Natchez, Hempstead, Tarrytown water works, etc.

PAYNE, CLARENCE QUINTARD, E.M., ... 1882.
136 Liberty St. and 9 W. Thirtieth St., New York City.

PEARIS, CHARLES FOWLER, E.M., ... 1884.
Box 374, Helena, Mont.

PECK, STAUNTON BLOODGOOD, C.E., M.E., . . . 1886.
Link Belt Machinery Co., Thirty-ninth Street and Stewart Avenue, Chicago, Ill., and 111 East Thirty-fourth Street, New York City.

One and a half years Mechanical Engineer, Burr & Dodge, Philadelphia. Two years Assistant Chief Engineer Link Belt Engineering Company, Philadelphia. Since 1888, Assistant Chief Engineer Dodge Coal Storage Company. Since 1890 and at present, Chief Engineer Link Belt Machinery Company, Chicago. Specialty, handling materials in bulk or package and power transmissions.

PEELE, ROBERT, JR., E.M., ... 1883.
Adjunct Professor of Mining, School of Mines, Columbia College, New York City.

1883, Assayer, Designolle Reduction Works, Charlotte, N. Carolina. 1883-84, Assayer and Assistant Supt. Silver-King Mining and Milling Co., Montezuma, Colorado. 1884-86, Foreman, Dry-crushing and Amalgamating Silver-mill, Silver-King Mining Co., Pinal, Arizona. 1886, went to England to examine systems of Sewage-disposal used in inland towns. 1887, Professional work as Assistant, in New York and Ari-

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zona. 1888, Examining gold-mines in Republic of Colombia, S. A. Supt. Mudsill Mining Co., Ltd., Fairplay, Colorado. Examinations and Ore-testing on Copper and Tin Properties, New Mexico and North Carolina. 1889, Examining Gold-placers, Dutch Guiana and South America. 1889–90, Supt. Oregon Gold-mining Co., Cornucopia, Oregon. 1890–92, Examining Silver-, Tin-, and Gold-mines in Peru, Bolivia, and Republic of Colombia, S. A., for the Peruvian Exploration Syndicate, Ltd., London, and Lima, Peru. 1892, Adjunct Prof. of Mining, School of Mines, Columbia College.

PELLEW, CHARLES ERNEST, E.M., ... 1884.

College Physicians and Surgeons, 437 West Fifty-ninth Street, and 51 East Fifty-fourth Street, New York City.

1884–85, studied chemistry at Lehigh University and Bethlehem Steel Works 1885–87, studied chemistry, physics, microscopy and bacteria at School of Mines and at College Physicians and Surgeons. Private Assistant to Professor Chandler. 1887 to date, Instructor and, later, Demonstrator in Physics and Chemistry at College Physicians and Surgeons. Hon. Fellow in Applied Chemistry, School of Mines. Also in general chemical practice with Professor Chandler (as partner). Specialty, chemical and other expert work, including medical and sanitary questions, *e.g.*, toxicology. Also as patent expert in chemical and physical subjects.

PENNINGTON, JOSEPH POPE, A.M. (Associate), . . . 1868.

40 Wall Street, New York City.

Assistant Engineer E. T. V. & G. R.R. 1881–83, Engineer Tombstone Mill and Mining Company. 1883–84, 1885 *et seq.*, railroad construction with general contractors. Assistant Secretary Louisville, St. Louis and Texas Railway. Previous responsibilities in connection with life insurance interests.

PERKINS, THOMAS SLADE, PH.B., ... 1888.

Ninth Street and Gowanus Canal, South Brooklyn, and 39 Garden Place, Brooklyn, N. Y.

1889 to date, New York Tartar Company.

PIERCE, FREDERICK EMERY, C.E., ... 1893.

New Jersey Steel and Iron Co., Trenton, N. J., and 22 W. Forty-fifth Street, New York City.

Learner in Bessemer Mill, Maryland Steel Co., Sparrows Pt., Maryland. Draughtsman, New Jersey Steel and Iron Co., Cooper, Hewitt & Co., New York City.

PISTOR, WILLIAM, E.M., ... 1868.

Architect, No. 1 Madison Ave. and 201 W. Fifty-fifth St., N. Y. City.

PITKIN, LUCIUS, A.B., PH.B., ... 1881.

138 Pearl Street, New York City.

1881–85, Chemist to Laurel Hill Chemical Works, of Nichols Chemical Company. Heavy chemicals, especially sulphuric acid. 1885 to date, Analytical and consulting Chemist, at above address. Specialty, in consulting. Manufacture of acids and heavy chemicals, treatment of pyrites and copper smelting. Analytical work. General, but special experience in argentiferous and auriferous copper-ores and products. Microscopical and experimental investigations.

POLLEDO, YSIDORO YGNACIO, E.M., ... 1885.

Santa Barbara Sugar Works, Baro, and Apartado 16 F., Matanzas, Cuba.

PORTER, HENRY HOBART, JR., E.M., ... 1886.

Westinghouse Electric and Mfg. Co., 120 Broadway, and 42 East Forty-first Street, New York City.

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1886–87, Fellow in Geology, School of Mines, Columbia College. 1887–88, Surveyor and Assayer Mexican Ore Company, Sierra Mojada, Mexico. 1888–89, Assistant Mining Engineer Batopilas Mining Company, Batopilas, Mexico. 1889–90, Surveyor and Assayer, Duquesne Mining Company; Assistant Superintendent, Ray & Poorman mine examinations, same company; Assistant Superintendent Sierrita County, Arizona, same company. 1890–91, Engineer with C. W. Hunt Company. 1891–92, Westinghouse Electric and Mfg. Co.

PORTER, JOHN BONSALL, E.M., PH.D., ... 1882.
C. H. & D. R.R. Co., Cincinnati and Glendale, O.

Assistant Engineer and Expert in tests of metals for various railways and corporations. Lecturer on Mechanical Engineering and Metallurgy in University of Cincinnati for some years. At present and for several years past, Engineer Maintenance of way, C. H. & D. R.R. system. Headquarters, Cincinnati, O.

POST, ABRAM SKIDMORE, C.E., ... 1884.
Great Neck, N. Y., and 173 Madison Avenue, N. Y. City.

POST, ALBERTSON VAN ZO, C.E., ... 1889.
45 Wall Street, and 4 East Sixty-second Street, New York City.

1889–90, Division Engineer, construction, Baltimore and Eastern Shore Railroad. 1891 to date, with the Railroad Equipment Company, of 45 Wall Street, New York City.

POTTER, WILLIAM BLEECKER, A.B., E.M., . . . 1869.
Professor Metallurgy and Mineralogy, Washington University, St. Louis, Mo.

POWELL, FREDERICK, A.B., E.M., ... 1883.
Address unknown.

POWERS, LOUIS J., JR., E.M., ... 1884.
Connecticut River Paper Company, Holyoke, and 4 Mattoon Street, Springfield, Mass.

1885, Superintendent Vermont Construction Company, St. Albans, Vt. 1886, Superintendent Standard Pulp Company, Springfield, Mass. 1887–88, Assistant Superintendent Union Manufacturing Company, Holyoke, Mass. 1888 to date, Agent Connecticut River Paper Company, Holyoke, Mass.

PRESTON, WILLIAM EVAN, C.E., ... 1889.
U. S. A. Building, 39 Whitehall Street, and 1427 Washington Avenue, Newark, N. J.

1889 to date, submarine blasting and dredging for U. S. harbor work with grapple, divers and centrifugal pump.

PROVOST, ANDREW JACKSON, JR., C.E., ... 1889.
Municipal Building, and 403 Washington Avenue, Brooklyn, N. Y.

1889 to date, Assistant Engineer in Sewage Construction, Department City Works, Brooklyn, N. Y.

R.

RANDOLPH, JOHN COOPER F., A.B., A.M., E.M., . . 1869.
Consulting Mining Engineer, 120 Broadway, New York City.

Graduated: Princeton, 1866, and School of Mines, New York City, 1869. 1869–71, in Germany, service of U. S. Govt. 1874, in service Japanese Govt. 1884, in Central China for a Chinese Syndicate. 1887, Resident Manager of La Plata Mines, Republic

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of Colombia, S. A.; National Commissioner of Mines for Tolima, Republic of Colombia, S. A. 1890, Resident Manager in Borneo of Borneo Diamond Exploration Syndicate, Ltd. For 23 years actively engaged in Professional Work in the United States, Mexico, etc. At different times Member of Council and Vice-president of the American Institute of Mining Engineers. 1891, sick. 1892, all the year in Mexico and Colorado. 1893, in Sonora and Virginia.

RANDOLPH, JAMES FITZ, B.S., E.M., ... 1876.
Communipaw Coal Co., 111 Broadway, New York City.

RAYMOND, ROBERT MATTHEW, A.B., E.M., . . . 1889.
Diamond (R) Mining Co., Neihart, Mont.

1880–82, Assistant Assayer, State of Maine Assay Office, Portland, Me. 1882–86, Assayer and Assistant Superintendent, Haile Gold Mine, S. C. 1886–89, School of Mines. 1889–90, Assayer and afterwards Assistant Superintendent, Montana Smelting Co., Great Falls, Mont. 1891, Superintendent, The Diamond Mining Co., Neihart, Mont.

RAYNOR, RUSSELL, PH.B., ... 1889.
25 E. One Hundred and Tenth Street, New York City.

Sept., 1889, to Aug., 1891, Chemist, with Martin Kalbfleisch Sons Co. Sept., 1891, to April, 1892, Assistant Chemist, Barber Asphalt Co.

RECKHART, DANIEL WILLIAM, E.M. (Life Member), . 1884.
Reckhardt & Heckelman, Assayers, Box 88, El Paso, Texas.

RECKHARDT, GEORGE FREDERICK, C.E., ... 1892.
C. E., 500 W. Thirty-fifth Street, New York City.

REED, SYLVANUS ALBERT, A.B., A.M., E.M., PH D., . 1877.
Traders' Building, Chicago, and University Club, New York City.

1878, Secretary to Assistant Commissioner General, Paris Exposition. 1879, Lectured on Chemistry. Reported on Mines in Colorado. 1880–84, Superintendent and part Proprietor, Sampling and Concentration Works in Colorado, and Reported on Mines there and in Idaho and in the South. 1886, Consulting Practice in New York, Patent Expert work and on Dredging in New York Harbor. 1886–91, Superintendent Inspection Department of Fire Insurance Co. (Commonwealth, of New York). 1893, Expert for New Insurance Rating, Mercantile Section of Boston. May, 1893, appointed Manager Western Factory Insurance Association.

REES, BENJAMIN FRANKLIN, E.M., ... 1874.
17 Ferry St. and 1425 Broadway, N. Y. City, and Chattanooga, Tenn.

At Milwaukee, Wis., in Real Estate business, 1875 to 1878. Since 1878 engaged in the leather business.

REES, JOHN KROM, AB., A.M., E.M. (Life Member), . 1875.
Prof. Geodesy, Practical Astronomy, and Director of Observatory, Columbia College, and 1 W. Seventy-second Street, New York City.

Assistant in Mathematics, School of Mines, 1873–76. Professor of Astronomy and Mathematics, Washington University, St. Louis, Mo., 1876–81. Member Fort Worth Solar Eclipse Party, July, 1878. Instructor in Geodesy, etc., Columbia College, 1881–82. Adjunct Professor in Geodesy, etc., Columbia College, 1882–84. Professor in Geodesy, etc., Columbia College, 1884 to date. Director of Observatory, Columbia College, 1881 to date. Chairman of Board of Editors, SCHOOL OF MINES QUARTERLY, 1883–90.

RENAULT, GEORGE, C.E., ... 1883.
61 Irving Place, New York City.

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RESTREPO, CAMILO CLAUDIO, E.M., C.E., . . . 1887.
D. Delastro & Co., 54 William St., and Box 1609, New York City.

RHODES, FRANCIS BELL FORSYTH, E.M., . . . 1874.
National S. & R. Co., South Chicago, Ill., and Quebec, Canada.

May, 1875, to December, 1876, Surveying Corps, Coxe Bros., Drifton, Pa. January, 1877, to May, 1878, Assistant Superintendent, South American Mining Co., Venezuela. November, 1878, to June, 1879, Working at Lead Mine, Canada. October, 1879, to April, 1880, Laborer, Ontario Mill, Park City, Utah. April, 1880, to July, 1881, Assistant Superintendent, Minge Furnace Co., Utah. August, 1881, to January, 1882, Assistant Superintendent St. Helena Mine, Sonora, Mexico. January, 1882, to April, 1883, Assistant Superintendent, Tombstone M. and M. Co., Arizona. May, 1883, to December, 1883, Superintendent, Ramsham Smelting Furnace, Idaho. January, 1884, to May, 1885, Assistant Superintendent, Minge Furnace Co., Utah. June 1885, to December, 1885, Foreman of Blast-furnace Department, Kansas City S. and R. Co. October, 1886, to December, 1889, Superintendent, Chicago Works, Chicago and Aurora S. and R. Co. January, 1890, to date, Superintendent National S. and R Co., South Chicago.

RHODES, ROBERT DUNN, E.M., ... 1879.
Supt. Arkansas Valley Smelting Works, Leadville, Col., and Box 726, Quebec, Canada.

1879–80, Foreman, Germania Smelting Co., Salt Lake City. 1880–82, Night Foreman, Ontario Silver Mining Co., Park City, Utah. 1882–83, Superintendent, Tombstone M. and M. Co. Reduction Works, Charleston. 1883–84, Mill Foreman, St. Helena Gold and Silver Mine, Sonora. 1884–85, Assistant Superintendent, Billing Smelter, New Mexico. 1885–86, Assistant Superintendent, Viola M. and S. Co., Idaho. 1887–88, Assistant Superintendent, Anglo-Mexican Mining Co., Yedras, Mexico. 1889–91, General Superintendent, Duquesne M. and R. Co., and Sierrita County, Arizona. 1891–92, Engineer Fraser & Chalmers, City of Mexico. 1892–93, Supt. as above.

RICE, GEORGE SAMUEL, JR., E.M., ... 1887.
Whitebreast Fuel Co., 119 S. Market St., Ottumwa, Iowa.

1888, Assistant Field Engineer, Colorado & Utah Railway. 1888–89, Assistant Mining Engineer of Colorado Fuel Co. 1890 to date, Mining Engineer of Whitebreast Fuel Co.

RICH, JACOB MONROE, E.M., C.E. (Life Member), . . 1883.
50 W. Thirty-eighth Street, New York City.

Pursuing further studies since graduation.

RICHARDSON, JOHN CLARENCE, E.M., C.E., . . . 1883.
Address unknown.

RICKETTS, PIERRE DEPEYSTER, E.M., PH.D., . . . 1871.
Professor, Analytical Chemistry, Columbia College, School of Mines, and 115 E. Seventy-ninth Street, New York City.

1868, Assistant, General Chemistry, Columbia College. 1871–72, Assistant in Mineralogy and Metallurgy, School of Mines. 1872–75, Assistant in Assaying, School of Mines. 1875–86, Instructor in Assaying, School of Mines. 1886 to date, Professor of Assaying, School of Mines. Since graduation also engaged in general Metallurgical, Chemical and Mining Engineering work.

RIDSDALE, THOMAS WEDDLE, E.M., ... 1883.
H. R. Worthington, 145 Broadway, New York City, and Montclair, N. J.

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Assistant Superintendent of the Ruby Durango Mine, and Wilder-Macdonald Concentrating Mill to 1884. Superintendent of the Wilper-Macdonald Mill, 1884. From 1888 with the Worthington Pumping Engine Co. From June, 1889, as Secretary of the Co.

RIES, HENRY, PH.B., ... 1892.
202 West Sixty-first Street, New York City.

ROESER, FREDERICK, B.S., E.M., ... 1884.
240 West 130th Street, New York City.

ROGERS, OSCAR LEGARÉ, PH.B. (Arch.), ... 1889.
No. 1 Madison Avenue and 57 West Eighty-fifth Street, New York City.
1889–92, in Europe. 1893, Architect as above.

ROLKER, CHARLES M., E.M. (Life Member), . . . 1875.
18 Broadway, New York City.
1868–70, At Royal School of Mines, Clausthal, Germany. 1871–72, Working practically in Iron Mines of Hibernia and Mt. Pleasant, N. J., Wisconsin Lead Mines and Iron Mines of Lake Superior. 1872–75, At School of Mines, Columbia College. 1876, Assayer at Allouez Copper-dressing Works, Lake Superior. 1877, Mining Engineer to the Mariposa Land and Mining Co., Mariposa Co., Cal. (Gold). 1878, Superintendent, Brooklyn Company, Washoe Co., Nevada (Base Metal). 1879, Superintendent. Stormont Silver Co., Silver Reef (Silver). 1880–82, General Manager, Chrysolite S. Mg. Co., Leadville, Colo. (Lead Carbonates). Since then to date, in General Consulting Practice as Mining Engineer and Metallurgist, Examining Mines, Mills and Placers, in the United States, Old Mexico, Central America, South America and East Indies. Specialty, Precious and Base Metals other than Iron.

ROOD, ROLAND GOUVERNEUR, PH.B., ... 1884.
Care Prof. O. N. Rood, Columbia College, New York City.

ROSENTHAL, ALBERT, C.E., ... 1892.
East River Bridge Co., 103 Broadway, Brooklyn, N. Y., and 158 East Seventy-ninth Street, New York City.

ROWLAND, CHARLES BRADLEY, C.E., ... 1884.
Continental Iron Works, Brooklyn. N. Y.. and 329 Madison Avenue, New York City.

ROWLAND, GEORGE, C.E., ... 1887.
Continental Iron Words, Brooklyn, N. Y., and 329 Madison Avenue, New York City.

RUPP, PHILIP, PH.B., M.D., ... 1884.
84 Second Avenue, New York City.
1884–87, Student in Medicine, College of Physicians and Surgeons, N. Y. 1887–88, House Physician and House Surgeon, St. Francis Hospital, N. Y. 1888 to date, Practicing Physician.

RUTTMANN, FERDINAND, JR., E.M., ... 1880.
35 Broadway, New York City.

RYON, AUGUSTUS MEADER, E.M., ... 1886.
President and Prof. Engineering, College of Agriculture and Mechanic Arts, Bozeman, Montana.
1886–87, Assistant Engineer on New London Water Works. Assistant in Metallurgy, School of Mines, Columbia College. 1887–88, Assistant to F. N. Owen, Civil

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and Sanitary Engineer, New York City. 1888-91, Professor of Engineering and Mining, School of Mines, College of Montana, Deer Lodge, Mont. 1892 to date. President and Professor of Engineering, Montana College of Agriculture and Mechanic Arts, Bozeman, Montana.

S.

SAGE, EDWARD EUGENE, C.E. (Life Member), . . . 1877.
United States Assay Office, 30 Wall Street, and 77 Hillside Avenue, Orange, N. J.

I have been connected with this office since February, 1879, and have consequently no outside experience except in electricity, being President of the Essex County Electric Co., of Orange, N. J., and in Analytical Chemistry.

SANDS, FERDINAND, A.B., PH.B., ... 1882.
Drugs and Assaying Supplies, Box 1172, Butte, Mont.

SCHERMERHORN, FREDERICK AUGUSTUS, E.M. (Life Member), ... 1868.
41 Liberty Street, and 61 University Place, New York City.

SCHIEFFELIN, WILLIAM JAY, PH.B., PH.D. (Munich), . 1887.
Schieffelin & Co., 170 William Street, and 35 West Fifty-seventh St., New York City.

SCHNEIDER, ALBERT FRANCIS, E.M., C.E., . . . 1876.
St. Louis Smelting and Refining Co., Box 504, St. Louis, Mo.

1876-1877, In Europe visiting Smelting and Dressing Works. 1878, Chemist and Assayer Germania S. and R. Co., Salt Lake City, Utah. 1879, Foreman, Assistant and Superintendent Germania S. and R. Co., Salt Lake City, Utah. 1880-'83, Superintendent Germania S. and R. Co., Salt Lake City, Utah. 1883-'85, Superintendent G. Billing Smelting Works. Socorro, N. M. 1885-'87, Superintendent Kansas City S. and R. Co., Argentine, Kansas. 1887, Connected with the Rio Grande S. Co., Socorro, N. M. 1887 to date, General Manager St. Louis S. and R. Co., St. Louis, Mo. Specialties, Concentration and Dressing of Ores. Metallurgy of Silver-Lead Ores. Refining bullion.

SCHUMANN, CHARLES HENRY, C.E., ... 1888.
12 Second Street, New York City.

1888, May, 1890, Assistant Engineer Chesapeake and Ohio Railway Co., Cincinnati, charge of Real Estate, Right of Way and Track and Construction work. May to August, 1890, Assistant Engineer to H. Alber, C. E., Birmingham, Ala., General Engineering. August, 1890 to March, 1891, Assistant Engineer Chesapeake and Ohio Railway Co., charge of subdivision of Town of West Clifton Forge, Va., and Right of Way on line of road. 1893, Assistant Engineer Long Island R. R., and Engineer for Ferris & Richards, Contractors for Railroads and Waterworks, at 98 Hudson St., Jersey City, N. J.

SELIGMAN, JOSEPH GUY, E.M., ... 1887.
Mining Superintendent, and 69 W. Ninety-fifth St., New York City.

SHARE, WILLIAM WALDEMAR, PH.B., PH.D., . . . 1881.
Adelphi Academy, and 331 McDonough Street, Brooklyn, N. Y.

1881, Superintendent Columbia Chemical Works, Brooklyn, N. Y. 1881 to 1888, Assistant Physics, Columbia College. 1888, Consulting Electrician, Department of Public Parks, Brooklyn, N. Y. 1889 to date, Professor of Chemistry, Adelphi Academy, Brooklyn, N. Y.

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SHRIVER, HENRY TOWER, PH.B., ... 1888.
T. Shriver & Co., 333 E. Fifty-sixth Street, and 686 Park Avenue, New York City.
In Iron Foundry and Works, as above since graduation.

SCHROTER, GEORGE AUSTIN, E.M., ... 1893.
1525 Blake Street, Denver, Colo.

SIMONDS, FRANCIS MAY, E.M., PH.D., ... 1887.
Assistant in Assaying, Columbia College, School of Mines, and 147 E. Thirty-fourth Street, New York City.

SINGER, GEORGE, JR., E.M., ... 1880.
111 Fourth Avenue, Pittsburgh, Pa.

SINGER, GEORGE HARTON, E.M., ... 1880.
Singer, Nimick & Co., and 17 Park Street, Allegheny, Pa.

SKINNER, ELMER, C.E., ... 1891.
227 Cumberland Street, Brooklyn, N. Y.

SLACK, CHARLES GODDARD, E.M., ... 1884.
Marietta, Ohio.

SLADE, RICHMOND EDWARD, PH.B., ... 1887.
White Plains, N. Y,
1887, Assistant Superintendent United Gas Improvement Co., Yonkers, N. Y., Plants. 1888, Superintendent Gas Department, Asheville (N. C.), Light and Power Co. 1889, Superintendent Gas and Electric Plants, Citizens' Gas Light Co., Jackson, Tenn. December, 1889 to date, Secretary, Superintendent and Trustee Citizens Gas and Electric Co., White Plains, N. Y.

SMITH, AUGUSTUS, A.B., C.E, ... 1889.
Link-Belt Eng'g Co., 49 Dey Street, and 460 W. Forty-fourth Street, New York City.
Summer of 1886, Land Surveying (in charge of Party). July and November, 1889, Draughtsman, Link Belt Engineering Co., Nicetown, Phila. November, 1889-91, Chief Draughtsman, Link Belt Engineering Co. 1891-92, out of Professional work. 1892, Salesman and Engineer as above.

SMITH, FRANK MARSHALL, E.M., ... 1889.
Assist. Supt. Colorado Smelting Co., Pueblo, Colo.
1889-1890, On the United States Geological Survey, engaged in hydrographic work on the Irrigation Survey and triangulation on the Topographic Survey, in Idaho and Oregon. 1891, Assayer Colorado Smelting Co., Pueblo, Colo. October, 1892, to date, Assistant Superintendent.

SMITH, FRANCIS PITT, PH.B., ... 1888.
Mamaroneck, N. J.
Analytical Chemist in Leather trade, 1888-'89. Superintendent Chemical Works, Wm. H. Swift & Co., East Boston, Mass., 1889-'90. Consulting Chemist, Dening & Logan, 58 William Street, 1890. Assistant Chemist New York City Health Department, 42 Bleecker Street, 1890-92. Specialty, Chemical Mechanics. 1892-93, Inspection Brooklyn Navy Yard.

SMITH, LENOX, A.B., A.M., E.M. (Life Member), . . 1868.
120 Broadway, New York City.

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SMITH, WILLIAM ALLEN, E.M., ... 1868.
52 Wall Street, New York City, and Pelham Manor, N. Y.

SMYTH, CHARLES HENRY, JR., PH.B., ... 1888.
Professor of Geology, Hamilton College, Clinton, N. Y.

1888–89. Chemist Franklin Iron Mfg. Co. 1889-90, Geological Field Work in New York, Alabama, Georgia, and Tennessee. June, 1890, received Degree of Doctor of Philosophy from Columbia College. 1890-91, studied Petrography and Mineralogy with Prof. Rosenbusch at the University of Hiedelberg. 1891, appointed Professor of Geology in Hamilton College. Engaged in the study of the Western Adirondack region, and the investigation of Problems in Central New York. Chiefly in Photographic, Chemical and Glacial Geology.

SNOOK, THOMAS EDWARD, E.M., ... 1884.
Architect, 12 Chambers Street, New York City.

Of firm John B. Smith & Sons, Architects.

SOUTHARD, GEORGE CARROLL, C.E., ... 1892.
Heine Safety Boiler Co., 136 Liberty Street, New York City, and 114 Brooklyn Avenue, Brooklyn, N. Y.

June, 1892, to March, 1893, Equity Gas-Works Construction Co., Brooklyn, E. D. March, 1893, to date, with Heine Safety Boiler Co.

SPOONER, ALLEN NEWHALL, C.E., ... 1886.
Department of Docks, Pier A, North River, New York City, and 186 Carteret Avenue, Jersey City, N. J.

July, 1886 to August, 1887, Rodman and Draughtsman, Penn R.R., Jersey City. August, 1887 to May, 1890, Hydrographer Department Docks, New York City. May, 1890–1891 to present time, Assistant Engineer Department Docks, New York City. Specialty, Railroad Engineering, River Submarine and Harbor Engineering.

STANTON, FRANK MCMILLAN, E.M., ... 1887.
Superintendent Atlantic Mine, Houghton Co., Mich.

1887–1888, Superintendent Pro tem Central Mine Mich. 1888–1889, Engineer Atlantic Mine, Mich. 1889 to date, Superintendent Atlantic Mine, Mich.

STAREK, EMIL, LL.B., LL.M., E.M., ... 1885.
Keller & Starek, Patents, Room 303 Times Building, Broadway and Chestnut St., St. Louis, Mo.

1885–1887, Assistant in United States Geological Survey. 1887 to 1892, Assistant Examiner United States Patent Office, Washington, D. C.

STARR, CHANDLER DANNAT, C.E., ... 1881.
Address unknown.

STAUNTON, JOHN ARMITAGE, JR., E.M., A.B. (Harvard), . 1887.
232 W. Forty-fifth Street, New York City.

1887–88, Instructor in Mathematics, Rochester, N. Y. 1888-90, Student in Harvard University. 1890-92, Student in the General Theological Seminary, N. Y. 1892-93, in charge of Church of the Holy Trinity, Wallace, Idaho. 1893, Assistant at Church of St. Mary the Virgin, New York City.

STAUNTON, WILLIAM FIELD, E.M., ... 1882.
Superintendent Tombstone Mill and Mining Co., Tombstone, Arizona.

1882, Assayer and Assistant Superintendent Vermont Copper Co., Ely, Vt. 1882, Assayer and Accountant Dunn Mt. Gold Mine, Salisbury, N. C. 1883, Assayer Ledoux & Ricketts, N. Y. 1883, Constructing Engineer, C. M. and R. Co., N. Y. 1883,

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Assistant to Manager of Mills and Smelter of T. M. and M. Co., Tombstone, Arizona. 1884, Consulting Engineer, N. Y. 1884, Mining Engineer, for T. M. and M. Co., Tombstone, Arizona. 1890, to date, Superintendent Tombstone Mill and Mining Co., Tombstone, Arizona. Specialty, Gold and Silver Mining and Metallurgy.

STEARNS, THOMAS BEALE, E.M., ... 1881.
Mining Machinery, 4 Dack Block, Box 1545, Denver, Colo.

STONE, GEORGE CAMERON, PH.B., ... 1879.
New Jersey Zinc and Iron Company, Newark, N. J.

1879, Chemist, Booth & Edgar Sugar Refinery. 1879–82, Chemist with Potter & Riggs, St. Louis, Mo. 1882–91, with New Jersey Zinc and Iron Company, Newark, N. J., first as Chemist; since 1884, as Superintendent Blast-Furnaces.

STRUTHERS, JOSEPH, PH.B., ... 1885.
Tutor in Metallurgy, Columbia College School of Mines, and 624 East One hundred and thirty-sixth Street, New York City.

1885–88, Fellow in Mineralogy. 1880–90, Assistant in Mineralogy and Metallurgy. 1891, Tutor in Metallurgy Columbia College, School of Mines.

STUART, WILLIAM HENRY, C.E., ... 1886.
47 Liberty Street and 36 W. Seventieth St., New York City.

1886, on railway surveys in Minnesota and Wisconsin with C. B. & N. R.R. Co. 1887–89, Fellow in Engineering and Assistant in Summer School of Surveying, School of Mines, Columbia College. 1889–90, making surveys and superintending construction at the Hudson River State Hospital, Poughkeepsie, N. Y. 1890, on surveys in the West Indies. 1893, in general practice.

SUTER, GEORGE AUGUSTUS, E.M., ... 1883.
G. A. Suter & Co., Engineers and Contractors, 139 South Fifth Avenue, New York City, and 206 Marcy Avenue, Brooklyn, New York.

1884-92, Engineer, Baker, Smith & Co. 1892 to date, as above.

SWAIN, ALFRED ERNEST, E.M., ... 1881.
Supt. Trinidad Mining Co., Copala (via Mazatlan, Sinaloa, Mexico, and 902 Prospect Street, Cleveland, O.

1881–84, railroad work in Mexico. 1886–88, City Engineer's Department, Kansas City, Mo., in charge of sewer work. 1889–91, mining work in Mexico. 1891, Supt. San Buenaventura Mining Company, Santa Lucia, Sinaloa, Mexico, via Mazatlan and Panna. 1891–93, Supt. Trinidad Mining Co.

T.

TERHUNE, RICHARD HENRY, E.M., ... 1870.
General Superintendent Hanauer Smelting Works, Salt Lake City, Utah.

1870, Assistant to late J. W. Foster, geology of coal fields, Indiana. 1871, Griswold Steel Works, draughting, blowing steel, etc. 1872–77, Joliet Steel Company, draughting, inspecting steel rails and exploration of Callaway County, Missouri, for coal and iron. 1877–80, Superintendent and Assistant Superintendent Smelting Works in Utah. 1880–93, General Superintendent Hanauer Smelting Works, Utah. Specialty, construction and operation of lead smelting works.

THACHER, ARTHUR, C.E., E.M., ... 1877.
1227 Spruce Street, St. Louis, Mo.

1878–79, with Progreso Mining Company, Trimfo, Lower California, Mexico. 1879–83, Southern Arizona and Northern Mexico Mining and Milling. 1883–87,

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office in New York. Examining and reporting on mines and mills. 1887 to date, with Professor W. B. Potter, at St. Louis Sampling and Testing Works and Washington University. Lecturing on Metallurgy. Testing ores, etc. Examining and reporting on mines and mills. Superintendent Central Lead Co.

THOMAS, FREDERICK MAYHEW, E.M., ... 1885.
Box 204, Skaneateles, N. Y.

Leveller (Instrument man, etc.), on New York State Canals, from September, 1887 to November, 1889 (position resigned). Transit-man and leveller on preliminary railroad survey in Schoharie County, in spring of 1890. Transit-man and leveller on Syracuse water works during the winter of 1890–91.

THOMPSON, HENRY CLARK, C.E., ... 1886.
Lorillard Place, and One hundred and eighty-seventh and One hundred and eighty-eighth Streets, New York City.

TIBBALS, GEORGE ATWATER, C.E., ... 1883.
Continental Iron Works, and 148 Milton Street, Brooklyn, N. Y.

1883 to date, as above.

TIBBALS, SAMUEL GAYLORD, C.E., ... 1884.
Continental Iron Works, and 148 Milton Street, Brooklyn, N. Y.

1884 to date, as above.

TILDEN, GEORGE CYRUS, C.E., ... 1876.
State School of Mines, Golden, Colo., and 310 Closson Avenue, Brooklyn, N. Y.

1876–80, City Surveyor, Brooklyn, N. Y. 1880–81, Superintendent Dunderberg Mining Company, Georgetown, Colo. 1881–82, Chemist and Assayer, Denver, Colo. 1882 to date, Professor Analytical Chemistry State School of Mines, Golden, Colo. 1881 to date, Consulting Practice as Mining Engineer. Specialty, Analytical Chemistry and Assaying.

TITUS, WARREN HARRIOTT, E M., ... 1885.
Assisting Sanitary Engineer New York Board of Health, and Whitestone, N. Y.

TONNELÉ, THEODORE, PH.B, ... 1880.
West Dewees, Wood County, McKeesport, Pa.

TORREY, CHARLES HERBERT, PH.B., ... 1880.
Du Bois Mfg. Co., Ltd., 15 Britannia Street, King's Cross, London, Eng.

1880–83, Assistant in Qualitative Laboratory, School of Mines. 1883–85, teaching in New York Institute for Improved Instruction to Deaf Mutes, New York City. 1885–87, in the employ of the DuBois Manufacturing Company of New York, in their branch in London. 1887 to present, managing German branch of BuBois Manufacuring Company, at above address.

TOWER, ALBERT EDWARD, E.M., ... 1883.
Poughkeepsie Iron Company, Poughkeepsie, N. Y.

TOWER, FREDERIC WETHERWAX, E.M., ... 1887.
Assistant Examiner, Room 223, Patent Office, and 1400 L St., N. W., Washington, D. C.

1888 to date, as above.

TRAPHAGEN, FRANK WEISS, PH.B., PH.D., . . . 1882.
Professor Analytical and Applied Chemistry, College of Montana, Deer Lodge, Montana.

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1883–84, Chemist for Williams, Clark & Co., Fertilizers. 1884–87, Instructor in Chemistry and Physics, Staunton Military Academy, Staunton, Va. 1887, Professor of General, Analytical and Applied Chemistry and Assaying in the College of Montana and Montana School of Mines. 1884–87, Analytical and Consulting Chemist, Staunton, Va. 1887, Principal work, fertilizer, iron and steel, clays, etc. Analytical and consulting Chemist and Assayer, Deer Lodge, Mont. Assaying, miscellaneous analysis and legal work. 1890, Assayer for the Champion Consolidated Mining Company, Deer Dodge, Mont.

TRASK, GEORGE FRANCIS DONNELL, E.M., . . . 1887.
R. W. Hildreth & Co., 1305 Locust St., Philadelphia, Pa., and 2 Wall Street, New York City.

1888–90, Apprentice and Machinist, L. & N. Railroad. 1890–91, Draughtsman, L. & N. Railroad, Louisville.

TUSKA, GUSTAVE ROBITSCHER, B.S., M.S., C.E., . . 1891.
167 East Seventieth St., N. Y. City.

1891–92, Civil and Mechanical Engineer Link-Belt Engineering Co., Philadelphia. 1892–93, Bridge Engineer Long Island Railroad.

TUTTLE, EDGAR GRANGER, E.M., ... 1881.
Box 109, Eagle Pass, Texas, and San Felipe, Coahuila, Mexico.

1881, Assistant Engineer, Tilly Foster Iron Mine, Brewster, N. Y. 1881–82, Division Engineer, Wheeling & Lake Erie R. R., Toledo, O. 1882–83, Assayer and Mining Engineer, Silver City, New Mexico. 1883–85, Division and Office Engineer, Arizona & New Mexico Railroad, Lordsburgh, Arizona. 1885, Constructing Engineer at Mines, Arizona Copper Co., Clifton Arizona. 1885–89, Mining Engineer, Cambria Iron Co., Johnstown, Pa. 1889 to date, Superintendent, Alamo Coal Co., and Coahuila Coal Co., San Felipe, Coahuila, Mexico, or Box 109, Eagle Pass, Texas.

TUTTLE, WILLIAM WEY, E.M., ... 1867.
Farm and Loan Agent, Springfield, Mo.

TYLER, WALTER LINCOLN, C.E., ... 1887.
116–120 Front Street, and 1314 Pacific Street, Brooklyn, N. Y.

1887, Levelman and Transitman on the Roanoke & Southern Railroad, Va. 1888, With J. A. Latham, C.E., Providence, R. I. 1888–89, With F. N. Owen, E.M., Sanitary Engineer, New York City. 1889 to the present time, With The A. B. See Manufacturing Co., 116–120 Front Street, Brooklyn.

V.

VALUE, BEVERLY REID, E.M., ... 1884.
Address unknown.

VANDERPOEL, FRANK, E.M., ... 1875.
Chemist, The Celluloid Co., 295 Ferry St., Box 55, and 191 Roseville Avenue, Newark, N. J.

1875–78, Salesman, with E. B. Benjamin. 1878 to date, as above.

VAN ARSDALE, WILLIAM HENRY, A.B., A.M., E.M., . 1868.
Vice-President, Chicago and Aurora Smelting and Refining Co., Chicago, Ill.

VAN BLARCOM, ELBERT CHAMPLIN, C.E., . . . 1876.
Hidalgo, Mexico, Care H. de San Francisco Pachuca, and State Mining Bureau, Box 2085, San Francisco, Cal.

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VAN CORTLANDT, EDWARD NEWENHAM, E.M., . . 1885.
Tuxedo Park, N. Y.

VAN DYCK, EDWIN, PH.B., ... 1888.
5 Spencer Place, Brooklyn, N. Y.

VAN SINDEREN, ALVAN HOWARD, PH.B., . . . 1881.
Attorney and Counselor-at-Law, 15 Broad Street, and 80 E. Washington Square, New York City.

VAN VOLKENBURGH, EDWARD, JR., C.E., . . . 1888.
Morgan & Bartlet, 41 Wall St., New York City.

VAN WAGENEN, THEODORE FRANCIS, E.M., . . . 1870.
Consulting Engineer; President and General Manager of The Deming Ore Co., Deming, Grant County, New Mexico.

VOLCKENING, GUSTAV JULIUS, JR., MET. ENG., E.M., . 1888.
653 Lafayette Avenue, Brooklyn, N. Y.

VONDY, RUDOLPH HARRISON, E.M., ... 1882.
143 Liberty Street and 305 Montgomery St., Jersey City, N. J.
1882–83, Assistant Engineer, Tilly Foster Iron Mine. 1885–92, Chemist Phoenix Iron Works, Phoenixville, Pa. 1892, Supt. Plenty Hort'l and Skylight Works.

VON NARDROFF, ERNEST ROBERT, E.M., . . . 1886.
Instructor of Physics, Barnard College, N. Y. City, 485 Carlton Ave., Brooklyn, N. Y.

VULTÉ, HERMANN T., PH.B., PH. D., ... 1881.
Assistant in Quantitative Analysis, School of Mines, New York City, and New Rochelle, N. Y.
1881-2, Superintendent Columbia Chemical Works, Brooklyn, N. Y. 1883-91, Assistant Instructor in Analytical Chemistry, School of Mines. Engaged in investigating new Analytical Methods. Specialty, Commercial Organic Analysis, Expert in Oils, Fats, Soap, etc.

W.

WAINWRIGHT, JOHN HOWARD, PH.B., ... 1882.
Chemist, 402 Washington Street, New York City.

WALKER, ARTHUR LUCIEN, E.M., ... 1883.
Old Dominion Copper Co., Globe, Gila County, Arizona; also Keyser Building, Baltimore, Md., and Lock Box 56, Morristown, N. J.
1883–84, Chemist and Assayer, Old Dominion Copper Co., Globe, Arizona. 1885, Assistant Superintendent of same Co. 1886, Engaged in connection with Iron Metallurgy in New York City. 1887, Mechanical Engineer for Silver King Mining Co., Silver King, Arizona. 1888–93, Superintendent, Old Dominion Copper Co., Globe, Arizona. Also report on all classes of Mining and Metallurgical Property in Arizona.

WALLACE, WILLIAM JEFFERSON, PH.B., . . . 1886.
Architect, Whitestone, N. Y.

WALLER, ELWYN, A.B., A.M., E.M., PH.D., . . . 1870.
33 West Fifteenth Street, New York City.

WAMPOLD, LEO, PH.B., ... 1888.
204 Monroe Street, Chicago, Ill.

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WARD, DELANCY WALTON, PH.B., ... 1888.
Whitestone, N. Y.

WARNER, JOSEPH LOWREY, E.M., ... 1887.
419 Bailey Building, Seattle, Wash.

August, 1887, to August, 1888, Omaha and Grant Smelter, Denver, Assistant Assayer. August, 1888, to July, 1889, Examination of and Reports on Mines in Coeur d'Almes, Idaho, and in O'Kanagan Mining District, Washington. Manager, La Bellevue Mine, same district. July, 1889, to January, 1890, Assistant Superintendent and Amalgamator, Golden Monarch Mine, Oregon. January, 1890–92, Examination and Reports on Mines in Western Washington. Manager, Culver Mining Co. and V. P. Vermilion Iron Co. 1892, Examinations in Cascade Range. 1893, Examinations of Iron Deposits, Island of Texada, British Columbia.

WATSON, FREDERICK MORGAN, E.M., . . . 1885.
Mina Rayo, Casapalca, Peru (via Lima), and 403 Sibley Street, Cleveland, O.

1885, Assayer and Surveyor, La Maria Mining Co., Mexico. 1886–89, Engineer, Mill Superintendent, Sombrerete Mining Co., Mexico. Concentration and Lixiviation. 1890, Engineer for Peru Exploration Syndicate, Ltd., Peru. 1891 to date, Examining Engineer for Frecheville Bros. Special Experience in Roasting Rebellious Ores. Lixiviation by Russell Process and Superintendent as above.

WATSON, ROLLA BARNUM, Met. Eng., ... 1891.
403 Sibley Street, Cleveland, Ohio.

Assayer, Candemena, Mexico, 1891. Supt. Erection of Power Plant for Electric Street R. R., Atlanta, Ga., 1892.

WEDEKIND, EDWIN HUTTER, PH.B., ... 1889.
Lebanon, Pa.

WEED, WALTER HARVEY, E.M., ... 1883.
U. S. Geological Survey, Washington, D. C., and care S. R. Weed, South Norwalk, Conn.

1883 to date, Geologist on the U. S. Geological Survey. 1883–89, general geology of the Yellowstone National Park, especially of sedimentary rocks, with examinations of the adjacent mining regions. 1890, structural and economic geology of the country north of the Yellowstone Park, with special studies of the coal-fields of Montana. Specialty, economic and stratigraphic geology. Publications: "A Deadly Gas-spring in the Yellowstone National Park."—*Science.* "The Diatom-beds and Marshes of the Yellowstone National Park."—*Bot. Gazette.* "The Formation of Hot Spring Deposits."—Ninth Annual Report of the Director U. S. Geological Survey.. "Geysers."—SCHOOL OF MINES QUARTERLY. "Notes on the Coal-Fields of Montana."—SCHOOL OF MINES QUARTERLY. "The Cinnabar and Bozeman Coal-Fields of Montana."—*Bulletin Geological Society of America*, and other papers.

WEEKS, WILLIAM HUEY, PH.B., ... 1889..
42 Bleecker Street, and 789 Madison Avenue, New York City.

1889–90, Assistant Chemist New York Chemical Manufacturing Company. April, 1890, to date, Assistant Chemist Health Department, New York City.

WELCH, ALEXANDER MCMILLEN, PH.B. (Arch.), . . 1890.
Haydon Furn. Co., No. 1 West Thirty-Fourth Street and 447 Lexington Avenue, New York City.

1890–91, in architect's office; 1891–93, McKim Fellow, travelling in Europe; 1893 to date, as above.

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WELLS, JAMES SIMPSON CHESTER, PH.B., PH.D., . . 1875.
Columbia College, School of Mines, New York City, and Hackensack, N. J.

1875–79, Assistant in Quantitative Analysis, School of Mines. Vacation of 1877, spent as Night Superintendent Pennsylvania Lead Works. 1879–93, Instructor in Qualitative Analytical Chemistry, School of Mines.

WELS, PAUL OSCAR, B.S., E.M., ... 1887.
2113 Madison Avenue, New York City.

WENDT, ARTHUR F., E.M., C.E., PH.D., ... 1872.
Antofagasta, Chili, S. A., and 127 East Ninety-first Street, New York City.

WERTHEIMER, LEWIS, PH.B., ... 1887.
Western and Bedwell Streets, Allegheny City, Pa., and 316 W. Forty-fifth Street, New York City.

WHEELER, HERBERT ALLEN, E.M., ... 1880.
Washington University, St. Louis, Mo.

During 1880, Assistant Geologist in Utah, on U. S. Geological Survey. During 1881, Assistant Engineer Denver and Rio Grande Western Railroad, in Utah and Colorado, on location and construction. During 1882, Superintendent Vermont Copper Company, Ely, Vermont. From 1883 to date, at Washington University, St. Louis; Adjunct Professor of Mining; also Consulting Mining Engineer. Since 1891, Assistant Missouri Geological Survey.

WHITE, ROBERT DAVIS, C.E., ... 1892.
J. D. & T. E. Crimmins, 1043 Third Ave. and 39 E. Seventy-fourth Street, New York City.

WHITLOCK, HERBERT PERCY, C.E., ... 1889.
Assistant in Mineralogy, Columbia College, School of Mines, and 449 Park Avenue, New York City.

WIECHMANN, FERDINAND G., PH.B., PH.D., . . . 1881.
Instructor in Chemical Philosophy and Chemical Physics, Columbia College, School of Mines, and 147 W. Ninety-fourth St., N. Y. City.
Consulting Chemist American Sugar Refining Co., Brooklyn, N. Y.

WIENER, WILLIAM, A.M., PH.B., ... 1891.
Chemicals for Electro-plating, 87–89 Mechanic St. and 62½ Nelson Pl., Newark, N. J.

WILLIAMS, GRANVILLE WHITTLESEY, E.M., C.E., . . 1879.
333 Genesee Street, Utica, N. Y.

WILLIAMS, JOHN TOWNSEND, E.M., PH.B., . . . 1873.
Williams, Clark & Co., and 871 Madison Avenue, New York City.

WILLIAMS, WILLIAM FISH, C.E., E.M., ... 1881.
City Surveyor, Odd Fellows Bldg. and 31 Fifth St., New Bedford, Mass.

1890, while filling the position of Assist't Engineer to A. B. Drake, Civil Engineer, of New Bedford, I accepted the position of Chief Engineer to the Cumberland Lands, Ltd., of Stewart County, Tenn. P. O. address, Dover. 1892, Assistant Manager and Engineer to the same Company; later, Chief of the Dept. of Mining, Construction and Engineering, and also Assist't Manager in the same Company. 1893, resigned, and came to New Bedford. Elected City Land-Surveyor and City Engineer with the old title of City Surveyor to the City of New Bedford.

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WILLIS, BAILEY, E.M., C.E., ... 1878.
U. S. Geological Survey, Washington, D. C.

June, 1879, to July, 1881, Special Agent Tenth Census; sampler of iron-ores and student of iron deposits in States east of the Mississippi river. August, 1881, to June, 1884, Geologist in charge of Pacific division of Northern Transcontinental Survey, chiefly engaged in coal explorations in Washington, Oregon and Montana. July, 1884, to February, 1889, Assistant Geologist U. S. Geological Survey, working in Tennessee and North Carolina. March, 1889, to June, 1893, Geologist in charge of Appalachian division, U. S. Geological Survey, directing work and studying geologic problems of the Palæozoic rocks south of Pennsylvania. 1891-93, Editor of Geologic Maps for Folios of the Geologic Atlas of the United States.

WILSON, HERBERT M., C.E., ... 1881.
U. S. Geological Survey, Washington, D. C.

1881-82, Leveller and Transitman, afterwards Chief of Preliminary party, S. & D. R.R., Mexico. 1882-88, Topographer U. S. Geological Survey. 1889-90, Division Engineer, U. S. Irrigation Surveys. 1891, Geographer, U. S. Geological Survey.

WILSON, WILLIAM ALEXANDER, E.M., ... 1882.
University Club, Salt Lake City, Utah.

Assayer for two and a half years. Superintendent of Sampling Mill for two years. Superintendent of 30-Stamp Mill (dry crushing, chloridizing, amalgamating and lixiviating, capacity sixty tons per day) for five years. Specialty, treatment of silver and gold-ores and examining and reporting on mining properties. Superintending of Mining or Milling Operations.

WILTSEE, ERNEST.
Care Gen. N. H. Harris, Bunker Hill and Sullivan Mining Company, Crocker Building, San Francisco, Cal.

WILTSIE, ERNEST ABRAM, E.M., ... 1885.
Barnato Bros., Johannesburg, South African Republic.

1885-86, Assistant Chemist Edgar Thomson Steel Works, Braddock, Pa. 1886 to May, 1887, Chemist Colorado Coal and Iron Company, Pueblo, Colo. May, 1887, to August, 1888, Chemist for the Globe Smelting and Refining Company, Denver, Colo. August, 1888, to April, 1890, Assistant Superintendent North Star Mining Company, Grass Valley, Cal. April, 1890-91, Superintendent Menlo Mines, Grass Valley, Cal. January, 1892, Expert work, Nevada Co., Cal. January to August, 1892, with California State Mining Bureau. August, 1892, to January, 1893, Expert work through California. April, 1893, Manager Gold Mines for Barnato Bros., Johannesburg, So. Africa.

WINDOLPH, ERNEST PAUL, PH.B., ... 1892.
208 W. Twenty-fifth Street, New York City.

WITTMACK, CHARLES AUGUSTUS, M.S., PH.B., PH.D., . 1882.
79 West 87th Street, New York City.

WOOLSON, IRA HARVEY, E M., ... 1885.
Columbia College School of Mines, New York City.

1885-86, Assistant Geological Survey of New Jersey. 1886-87, Assistant Assay Department, School of Mines. 1887-89, Assistant Drawing Department, School of Mines. 1891 to date, Instructor Mechanical Engineering and Drawing, School of Mines.

Y.

YOUNG, EDWARD LEAVITT, E.M., ... 1882.
Agent Fraser & Chalmers, 2 Wall Street and 317 W. Eighty-ninth Street, New York City.

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HONORARY MEMBERS.

CHANDLER, CHARLES F., PH.D.
Professor of Chemistry, School of Mines, Columbia College. Address, 51 East Fifty-fourth Street, New York City.

EGLESTON, THOMAS, E.M., PH.D.
Professor of Mineralogy and Metallurgy, School of Mines, Columbia College. Address, 35 West Washington Square, New York City.

FISH, HAMILTON, LL.D.
Trustee of Columbia College. Address, 251 East Seventeenth Street, New York City.

MILLER, GEORGE M.
Ringwood, New Jersey.

ROOD, O. N., A.M.
Professor of Physics, Columbia College. Address, Columbia College, New York City.

VAN AMRINGE, J. H., A.M., PH.D.
Professor of Mathematics, School of Mines, Columbia College. Address, 66 West Forty-seventh Street, New York City.

WARE, WILLIAM R., B.S.
Professor of Architecture, School of Mines, Columbia College. Address, 126 East Twenty-eighth Street, New York City.

HONORARY MEMBERS DECEASED.

AGNEW, C. R.,	1888.
BARNARD, F. A. P.,	1889.
NEWBERRY, J. S.,	1892.
PECK, W. G.,	1892
RUTHERFURD, L. M.,	1892.
TROWBRIDGE, W. P.,	1892.

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LIST No. 3.

Contains the names of Graduates of the School of Mines, not members of the Alumni Association, nor participating in the benefits of such membership. For this reason great uncertainty prevails as to many of the addresses given, which are the best at hand.

It is very desirable that this list should be shortened as far as practicable by the transfer of names from it to the preceding List, No. 2, under the Rules.

(Revised to June, 1893.)

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Adams, W. J., A.M., E.M., ... 1878.
Room 15, No. 132 Market St., San Francisco, Cal.
Agramonté, José Cesar, C.E., ... 1876.
Address unknown.
Alden, Herbert C., E.M., ... 1884.
Address unknown.
Anderson, George Mendenhall, Ph.B., ... 1891.
East Walnut Hills, Cincinnati, Ohio.
Andresen, Charles Alfred, E.M., ... 1881.
Pickard & Andresen, 89 Gold Street, New York City.
Appleby, John Storm, Ph.B., ... 1888.
Architect, 216 West Fifty-ninth Street, New York City.
Aschman, Fred. Theo., Ph.B., ... 1881.
Chemist and Prof. Chemistry, College of Pharmacy, and 86 Water St., Pittsburgh, Pa.
Ayestas, Alberto, Ph.B., ... 1884.
Tegucicalpa, Honduras, C. A.

Barkley, Howell Finch, E. M., ... 1885.
233 West Fifty-fourth Street, New York City.
Barnard, Aug. Porter, E.M., ... 1868.
125 East Twenty-sixth Street, New York City.
Barros, Louis de Souza, E.M., C.E., ... 1877.
San Paulo, Brazil.
Beckstein, Charles Alfred, Ph.B., ... 1888.
336 West Forty-sixth Street, New York City.
Beckwith, Charles Ellsworth, Met. Eng., ... 1888.
South Baltimore, Curtis Bay, Md.
Beckwith, George Alexander, C.E., ... 1880.
Paterson, N. J.
Behlen, Herman, Ph.B., ... 1890.
125 East One Hundred and Fifteenth Street, New York City.
Behr, Edward, C.E., ... 1877.
Behr Bros. & Co., 298 Eleventh Ave., New York City.
Bell, Henderson, M., Jr., E.M., ... 1886.
Bramwell, Mercer Co., W. Va., and Staunton, Va.
Bergen, Chas. Hill, C.E., ... 1892.
Red Bank, N. J.
Berry, Gerald, C.E., ... 1889.
N. Y. Mutual Gas-Light Co., E. Eleventh Street, N. Y. City, and 78 Morton Street, Brooklyn, N. Y.
Betts, Romeo Thompson, C.E., ... 1890.
191 Halsey Street, Brooklyn, N. Y.
Bleecker, Charles Popham, E.M., ... 1881.
Atlantic Dredging Co., Bayonne, N. J.
Bliss, Collins Pechin, Ph.B., ... 1891.
60 Cedar St., Room 9, and 423 W. One Hundred and Fifty-fourth St., N. Y. City.
Bolles, Randolph, Ph.B., ... 1892.
Englewood, N. J.

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Bolton, Robert, Ph.B., ... 1879.
408 West Nineteenth Street, New York City.

Brennan, Andrew Joseph, C.E., ... 1885.
Address unknown.

Bridgham, Samuel Willard, E.M., ... 1867.
49 West Twenty-third Street, New York City.

Brinckerhoff, George Charles, E.M., ... 1878.
Apartado 183, Matanzas, Cuba.

Brinley, John Rowlett, C.E., ... 1884.
Morristown, N. J.

Bronson, Edward Stelle, A.B., A.M., E.M., ... 1867.
49 Garden Place, Brooklyn, N. Y.

Brown, Robert Gilman, E.M., ... 1889.
Supt. for W. A. Clark & Bro., Box 505, Butte, Mont., and 170 West Tenth Street, New York City.

Bruckman, Frederick, E.M., ... 1869.
U. S. Mint, and 130 West Third Ave., Denver, Colo.

Buckingham, Frederick Endicott, E.M., ... 1884.
Department Public Works, Brooklyn, N. Y.

Buckland, Will A., Ph.B., ... 1890.
36 East Twenty-Second Street, New York City.

Bush, William Falkner, E.M., ... 1885.
Address unknown.

Cady, Linus Bertram, E.M., C.E., ... 1877.
234 West Thirty-eighth Street, New York City.

Cary, Geo. B., Ph.B., ... 1885.
184 Delaware Avenue, Buffalo, N. Y.

Cairns, Fred. Irvan, E.M., ... 1890.
Ducktown Copper, Sulphur and Iron Co., Ducktown, Tenn.

Cameron, John Gedney Mott, E.M., C.E., ... 1874.
Assayer, Box 188, Nyack on-Hudson, N. Y.

Campbell, Alonzo Clarence, E.M., ... 1869.
Mining Engineer, 306 Russell Street, Nashville, Tenn. Specialty, Milling and Concentration.

Carrère, Joseph Maxwell, C.E., ... 1883.
36 Park Place, New York City, and New Brighton, N. Y.

Carson, Joseph, C.E., ... 1890.
31 West Fifty-fifth Street, New York City.

Churchill, Alfred Daniel, A.M., M.S., E.M., Ph.D., ... 1880.
Helena, Mont.

Clarke, Wm. Cowles, M.E., ... 1892.
Cranford, N. J.

Clayton, William Robert, Ph.B., ... 1890.
Architect, 31 and 32 Rialto Building, Chicago, Ill.

Cloud, Leo George, A.B., S.M., ... 1879.
216 Monmouth Street, Newport, Ky.

Colton, Frederick Gray, Ph.B., ... 1890.
136 Montague Street, Brooklyn, N. Y.

Comstock, Claude Nichols, C.E., ... 1888.
Address unknown.

Constant, Charles Louis, E.M., C.E., ... 1877.
32 Park Street, Jersey City, N. J.

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Cornwall, George Rockwell, E.M., C.E., ... 1876.
Wallbridge & Co., 27 Vanderwater Street, New York City.
Coursen, George Hampton, E.M., C.E., ... 1868.
Address unknown.
Coykendall, Thomas Cornell, C.E., ... 1890.
Rondout, N. Y.
Cozzens, Harmon, E.M., ... 1885.
Address unknown.
Cristy, Edward Buxton, Ph.B., ... 1891.
Greenwich, Conn.
Cromwell, James William, Jr., Ph.B., ... 1889.
Architect, 29 Brevoort Place, Brooklyn, N. Y.
Curtis, Charles Gordon, C.E., ... 1881.
President Curtis Electrical Mfg. Co., Whiton St., Jersey City, N. J.

Davis, William Monroe, E.M., ... 1890
Syracuse, N. Y.
Del Calvo, Francis, C.E., ... 1884.
Address unknown.
Denton, Frederick Warner, C.E., ... 1889.
Instructor Civil and Mining Engineering, Houghton, Mich.
Detwiller, Charles Henry, Ph.B., ... 1885.
Detwiller & Melendy, Bennett Bldg., Fulton and Nassau Sts., N, Y. City, and
56 Danforth Avenue, Jersey City, N. J.
Doolittle, Charles Horace, E.M., ... 1885.
Address unknown.
Downing, Orrien Pinkerton, Ph.B., ... 1878.
San Leandro, Cal.
Dunn, Gano Sillick, B.S., E.E., ... 1892.
Elect. Engineer, Crocker-Wheeler Electric Co., Newark, N. J.
Durham, Edward B., M.E., ... 1892.
Box 54, Minersville, Essex Co., and New Castle, N. Y.

Eliot, Walter Graeme, E.M., C.E., Ph.B., Ph.D., ... 1878
"University Magazine," 70 South St., and University Club, N. Y. City.
Escobar, Francisco, E.M., ... 1889.
Medelin, U. S. of Colombia, S. A.

Fales, William, E.S., E.M., LL.B., ... 1871.
Lawyer, 189 Montague Street, Brooklyn, N. Y.
Fenner, Clarence Norman, M.E., ... 1892.
80 Leonard Street, New York City.
Ferguson, George Albert, Ph.B., ... 1890.
138 Wilson Street, Brooklyn, N. Y.
Fisher, Lloyd Wiegand, Ph.B., ... 1890.
31 E. Seventeenth St. and 109 E. Twenty-eighth St., N. Y. City.
Fitch, Charles Lincoln, E.M., ... 1882.
Supt. San Pedro Mine, Sonora, Mexico, and 124 West Forty-second Street,
New York City.
Fitch, Josiah Huntingdon, E.M., ... 1884.
Address unknown.
Fitzgerald, George E., E.M., ... 1884.
El Paso, Texas.

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Francke, Robert Otto, C.E., ... 1880.
W. Passburg, Esq., Moscow, Russia.
Frankfield, Emil, C.E., ... 1886.
52 W. Fourteenth Street, and 328 W. Fifty-sixth Street, New York City.

Gage, Samuel Edson, Ph.B., ... 1887.
Architect, 114 Fifth Ave., N. Y. City, and Flushing, N. Y.
Gardner, Watts Denning, C.E., ... 1888.
Address unknown.
Garrison, Edmund Hoyt, E.M., C.E., ... 1876.
84 Highland Street, Yonkers, N. Y.
Geer, George Jarvis, Jr., E.M., ... 1868.
Merchant, 453 Broome Street, New York City.
Giddings, Edward Everett, E.M., ... 1867.
Merchant, 413 Royal Insurance building, Chicago, Ill.
Gillette, Halbert Powers, M.E., ... 1992.
Ketcham, Idaho.
Goldsmith, Byron Benjamin, Ph.B., ... 1887
Am. Lead Pencil Co., Hoboken, N. J., and 19 East Seventy-fourth St., N. Y. City.
Gould, Edward Ludlow, C.E., ... 1890.
59 Hawthorne Avenue, Yonkers, N. Y.
Granger, Abbott D., C.E., ... 1892.
198 Hooper Street, Brooklyn, N Y.
Greene, Wilkins Updike, Ph.B., ... 1880.
104 Columbia Heights, Brooklyn, N. Y.
Griffith, Vincent Colyer, Ph.B., ... 1889.
Architect, 114 Fifth Ave., N. Y. City, and 160 Herkimer Street, Brooklyn, N. Y.
Griggs, Wilfred Elizur, Ph.B., ... 1889.
Architect, Waterbury, Conn.

Haas, Harry Leopold, Ph.B., ... 1878.
Carrère and Haas, 36 Park Place, New York City.
Haffen, Louis Francis, A.M., C.E., ... 1879.
Commissioner Street Improvements, 141st St. and Third Ave, and 647 Courtlandt Avenue, 23d Ward, New York City.
Hamilton, Schuyler, Jr., A.B., A.M., E.M., ... 1876.
Croton-on-Hudson, Westchester Co., N. Y., Architect and Brick Manufacturer.
Harker, Charles Sumner, E.M., ... 1879.
Address unknown.
Harmer, Thomas Hayes, A.B., A.M., E.M., ... 1867.
113 East Twenty-seventh Street, New York City.
Harrison, Newton, E.E., ... 1892.
Elect. Engr., 136 Liberty St., New York City.
Hart, Burnham, C.E., ... 1885.
Care L. W. Hart, 44 Court Street, Brooklyn, N. Y., and Ramsay, N. J.
Out of health, unable to practice.
Hart, Charles Henry, C.E., ... 1890.
199 Lenox Avenue, New York City.
Hasegawa, Yothinosuke, E.M., Ph.D., ... 1878.
Mitsu Bishi Sha, No. 11, Awajicho, Nichome Kanda, Tokio, Japan.

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Hawkes, Emil MacDougal, A.B., E.M., ... 1885.
267 Fifth Avenue, New York City.

Hay, Arthur, M.E., ... 1892.
Springfield Iron Co., and 821 So. Second St., Springfield, Ill.

Heath, Frederick Milton, E.M., ... 1867.
Potsdam, N. Y.

Heinze, Frederick Augustus, E.M., ... 1889.
General Manager Montana Ore Producing Co., Butte, Montana.

Hemmer, Frederick Adolph, Ph.B., ... 1881.
52 Cedar Street, New York City.

Hooper, Louis Mosher, C.E., ... 1880.
Sanitary Department New York Board of Health, and care of J. B. Hooper, 80 Chambers Street, New York City.

Holter, Norman Bernard, E.M., ... 1891.
A. M. Holter Hardware Co., Helena, Mont.

Horn, James Thurston, A.B., C.E., ... 1884.
Naval Architect, and 13 E. Fifty-third Street, New York City.

Hornbostel, Henry Frederick, Ph.B., ... 1891.
39 Second Place, Brooklyn, N. Y.

Hoyt, John Sherman, C.E., ... 1890.
934 Fifth Avenue, New York City.

Hudson, Edward Henry, C.E., ... 1880.
Address unknown.

Huntting, Henry Ogden, Ph.B., ... 1887.
Architect, 454 Ceasson Avenue, Brooklyn, N. Y.

Huntington, Chester, ... 1.69.
Box 1780, New York City.

Ingram, Edward Lovering, C.E., ... 1885.
St. Augustine, Fla., and Nyack, N. Y., now U. S. Assistant Engineer. Harbor Engineering.

Ives, Arthur Stanley, C.E., E.E., ... 1889.
Engineer's Office, N. Y. and Brooklyn Bridge, and 33 Sidney Place, Brooklyn, N. Y.

Jackson, Charles Edward, C.E., ... 1875.
15 Courtland Street, New York City.

Jarmulowsky, Meyer, Ph.B., ... 1890.
27 Jefferson Street, New York City.

Jenney, Walter Proctor, E.M., Ph.D., ... 1869.
U. S. Geological Survey, Washington, D.C., and Joplin, Mo.

Johnston, Robert Andrew, C.E., ... 1879.
Attorney and Counsellor, 132 Nassau Street, New York City.

Jones, Thomas John, Met. Eng., ... 1890.
Pulaski City, Va.

Jordao, Jose Nabor Pacheco, C.E., E.M., Ph.B., ... 1877.
Paulista Railway, San Paulo, Brazil, S. A.

Judd, Charles Breck, E.M., ... 1881.
820 Penn Avenue, Pittsburgh, Pa.

Keeler, Frederick Sterling, Ph.B., ... 1891.
E. A. Kent, 94 White Bldg., Buffalo, N. Y., 106 East Thirty-eighth St., N. Y. City.

King, Charles, Ph.B., ... 1876.
Railroad contractor, King and Dickinson, Tacoma, Wash.

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Kletchka, John Joseph, A.B., C.E., ... 1892.
92 Vesey Street, New York City.

Kohn, Robert David, Ph.B., ... 1890.
108 West Sixty-fourth Street, New York City.

Korn, Louis, Ph.B., ... 1890.
261 Broadway and 924 Madison Avenue, New York City.

Klepetko, Frank, E.M., ... 1880.
Superintendent Smelting Department, Tamarack, Osceola Copper Manufacturing Co., Dollar Bay, Mich. At present Superintendent of Construction of the Great Falls Smelter, for the Boston and Montana Consol. Copper and Silver Mining Co. Address, Great Falls, Montana,

Knapp, John Augustus, A.B., A.M., E.M., ... 1870.
Chicago and Aurora Smelting Co., Chicago, Ill.

Knox, Charles E., E.E., ... 1892.
Jas. W. Queen & Co., Philadelphia, Pa.

Ledoux, Augustus Damon, Ph.B., ... 1881.
A. R. Ledoux and Co., 10 Cedar Street, New York City.

Lee, Henry Charles, C.E., ... 1886.
127 East Twenty-first Street, New York City.

Lichtenstein, Edward Gervaise, Ph.B., ... 1890.
50 Broadway and 14 W. Seventy-fourth Street, New York City.

Lindsley, Stewart, E.M., ... 1870.
Orange, N. J.

Livingston, Goodhue, Ph.B., ... 1892.
Geo. B. Post, Century Bldg., New York City.

Lord, Nathaniel Wright, E.M., ... 1876.
Professor Mining and Metallurgy, Ohio State University, Columbus, O.

Lowndes, William Shepherd, Ph.B., ... 1890.
42 Sherman Place, Jersey City, N. J.

McDowell, Frederick H., E.M., ... 1872.
117 Liberty Street, New York City and Montclair, N. J.

McIlheney, Parker C., Ph.B., ... 1892.
621 Grand Street, New York City.

McIlvaine, Alexis Reed, Ph.B., ... 1888.
Architect, 28 East Ninth Street, New York City.

McKinlay, James Buell, M.E., ... 1892.
H. H. Hodge, 29 Broadway and 108 W. Seventy-ninth St., New York City.

McKleroy, William Henry, Met. Eng., ... 1890.
Cashier Anniston National Bank, Anniston, Ala.

Maghee, John Holme, A.B., A.M., C.E., ... 1876.
Cayuga Lake Ice Line, Rochester, N. Y., and 16 East Fifty-fourth Street, New York City.

Mahl, J. Thomas, C.E., ... 1891.
Mills Building, New York City.

Mann, Horace Borchsenius, Ph.B., ... 1890.
Orange, N. J.

Mapes, Charles Halstead, Ph.B., ... 1889.
68 West Fortieth Street, New York City.

Marsh, Charles Wells, Ph.B., Ph.D., ... 1879.
Niftel & Moock Co., 126 Liberty St. and 435 Fifth Avenue, N. Y. City.

Matthews, Charles Thompson, Ph.B., ... 1889.
Architect, Elm Park, Norwalk, Conn.

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Matsui, Nawokichi, Ph.B., Ph.D., ... 1878.
Third High School, Osaki, Japan.
Mattison, Joseph Godley, Ph.B., ... 1880.
Real Estate and Insurance Broker, 20 West Fourteenth Street, New York City.
Meikleham, Thomas Mann Randolph, C.E., ... 1890.
52 Wall Street, New York City.
Meisel, Frederic, Ph.B., ... 1892.
367 Henry Street, Brooklyn, N. Y.
Mesa, Antonio Esteban, C.E., ... 1882.
Address unknown.
Moeller, Rudolph, Ph.B., ... 1887.
17 and 19 William Street, and 336 West Twenty-ninth Street, New York City.
Morewood, George Barrow, E.M., Ph.D., ... 1878.
Tea Importer, 132 Front St. and 156 W. Seventy-sixth St., New York City.
Morewood, Henry Francis, E.M., Ph.D., ... 1876.
Importer, Box 2087, New York City, and Englewood, N. J.
Mott, Henry Augustus, Jr., Ph.D., E.M., Ph.D., ... 1873.
Mining Engineer and Analytical Chemist, 61 Broadway, New York City.
Murray, George, E.M., ... 1874.
235 West Twenty-third Street, New York City.

Nambu, Kiugo, E.M., ... 1878.
Nagasaki, Japan.
Neymann, Percy, Ph.B., ... 1881.
Chemist and Assistant Superintendent, 36 Michigan St., Cleveland, O.
Nichols, Harry Parmelee, E.M., ... 1887.
2622 Third Ave. and Hotel St. George, 49 E. Twelfth St., N. Y. City.
Nichols, Ralph, E.M., C.E., ... 1877.
Manager Jay Gould Mine, Bullion & Haley, Alturas Co., Idaho.
Noble, Charles Milton, E.M., ... 1879.
Manager Ruttan Mfg. Co., Anniston, Ala.

Oseranski, Isaac Henry, C.E., ... 1889.
Address unknown.
Owens, Robert Bowie, E.E., ... 1892.
Professor Elect. Engineering, Univ. of Nebraska, Lincoln, Neb.
Oxnard, James Guerrero, Ph.B., ... 1883.
Fulton Sugar Refinery, Dock and Water Streets, Brooklyn, N. Y.

Palmer, Cortlandt Edward, E.M., ... 1878.
General Manager, Argentum, Juniata, etc., M. & M. Cos., Aspen, Colorado.
Parmly, Chas. Howard, B.S., E.E., ... 1892.
Tutor in Math., College of New York, New York City.
Pazos, Vincent Felix, E.M., ... 1878.
Care of Wm. R. Grace & Co., Hanover Square, New York City.
Perry, Nelson W., E.M., ... 1878.
Editorial Staff "Electrical World," New York City.
Pfister, Philip Charles, E.M., ... 1875.
Address unknown.
Pierce, Harry Nelson, E.M., ... 1885.
Address unknown.

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Piez, Charles, E.M., ... 1889.
Link Belt Engineering Co., Nicetown, and 430 Franklin Street, Philadelphia, Pa.

Platt, Charles Slason, E.M., ... 1868.
Assayer, 21 and 31 Gold St., New York City.

Portuondo, Jose, C.E., ... 1890.
San Basilio, Alta 28, Santiago, Cuba.

Post, William Stone, Ph.B., ... 1890.
Bernardsville, N. J.

Powers, Cornelius Van Vorst, Ph.B., ... 1882.
22 West Forty-eighth Street, New York City.

Primelles, Jose Alejandro, C.F., ... 1887.
Mercedes 23, Puerto Principe, Cuba.

Proctor, William Ross, E.M., ... 1884.
Pittsburgh, Pa.

Provot, George, Ph.B., ... 1889.
Architect, 24 Highland Terrace, Orange, N. J.

Radford, William Helsham, E.M., ... 1877.
Lydenburgh, Gold Mining Co., Limited, Manchester, Eng.

Randolph, Edmund, Ph.B., ... 1883.
E. & C. Randolph, 7 Nassau St., New York City; also Knickerbocker Club.

Raymer, George Sharp, A.B., E.M., ... 1881.
Mine Superintendent, Idaho Springs, Colorado, and 63 Seventh Avenue, Brooklyn, N. Y.

Raymond, Alfred, Ph.B., ... 1891.
(1893, in Europe); 123 Henry Street, Brooklyn, N. Y.

Reed, William Bell Stephen, E.M., ... 1879.
Address unknown.

Reese, William W., A.B., E.E., ... 1892.
Thomson-Houston Elect. Co., Lynn, Mass.

Richmond, William Thomas, Ph.B., ... 1881.
68 Thomas Street, New York City.

Riggs, Geo. Washington, Ph.B., ... 1871.
Ridgefield, Conn.

Roberts, Arthur Carr, E.M., ... 1881.
Address unknown.

Roberts, Gracie Sayre, E.M., C.E., ... 1871.
Sewer Bureau, Dept. City Works, Brooklyn, N. Y.

Robertson, Kenneth, E.M., ... 1868.
General Manager West Superior Iron and Steel Co., W. Superior, Wis.

Robertson, Richard Spotswood, Jr., E.M., ... 1871.
Jackson, Minn.

Robinson, Henry Alvord, Ph.B., ... 1880.
Lawyer, address unknown.

Rogers, Charles Louis, E.M., C.E., ... 1877.
823 Broad Street, Chattanooga, Tenn.

Ross, William Coleman, C.E., M.E., ... 1876.

Rutherford, Francis Morris, E.M., ... 1879.
Assistant Engineer, maintenance of way, R. & D. R. R., Richmond, Va.

Rutherford, Lewis Hopkins, E.M., ... 1887.
Franklin, Pa., and 470 Washington Street, New York City. 1888 to date, Manager American Oxide Co., as above.

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Sanders, Wilbur Edgerton, E.M., ... 1885.
Mine Supt., Ewing and Seventh Avenue, Helena, Mont.

Savage, Seward Merrill, C.E., ... 1892.
2260 Pacific Street, Brooklyn, N. Y.

Sawyer, Charles Pike, Ph.B., ... 1881.
Address unknown.

Shack, Albert P., E.M., ... 1868.
Address unknown.

Schroeder, James Langdon, C.E., ... 1889.
Renwick, Aspinwall & Renwick, 71 Broadway, and 27 East Thirty-first Street, New York City. July, 1890, to date, architectural draftsman.

Sherman, Frank Dempster, Ph.B., ... 1884.
Adj. Professor of Architecture, Columbia College, School of Mines, New York City.

Shope, Henry Brengle, Ph.B., ... 1885.
R. M. Hunt, Metropolitan Bldg., No. 1 Madison Ave., and 19 West Thirty-second Street, New York City.

Skidmore, Samuel Tredwell, A.B., Ph.B., ... 1889.
71 West Fiftieth Street, New York City.

Sloane, Thomas O'Connor, A.B., A.M., E.M., Ph.D., ... 1872.
361 Broadway, New York City, and South Orange, N. J. Chemist, expert in patent cases and author.

Small, Franklin Maurice, Ph.B., ... 1889.
Architect, 199 Second Avenue, New York City.

Smeaton, William Henry, C.E., E.M., ... 1877.
3 West Twenty-ninth St., New York City.

Smedberg, Henry Ashton, A.B., C.E., ... 1884.
347 Fifth Avenue, New York City.

Smith, Maxwell, C.E., ... 1880.
Adon Smith, 8 Bridge Street, New York City.

Smythe, Roland Mulville, E.M., C.E., ... 1877.
44 Broadway, New York City. 1879 to date, banker and broker.

Speyers, Clarence Livingston, Ph.B., ... 1884.
Associate Professor Chemistry, Rutgers College, New Brunswick, N. J.: also 50 West Seventeenth Street, New York City.

Stallnecht, Frederick, E.M., ... 1868.
Editor, 11 Bond Street, New York City.

Starr, Henry Fowler, Ph.B., ... 1879.
Chemist, Newark Steel Works, 38 Orleans Street, Newark, N. J.

Steers, James Aich, Ph.B., ... 1890.
10 East Thirty-eighth Street, New York City.

Stevens, Alexander, C.E., ... 1887.
P. O. Box 37; and No. 1 Newark St., Hoboken, N. J.

Stewart, Hunter, E.M., ... 1875.
Address unknown.

St. John, Thomas Matthew, Met. Eng., ... 1890.
New York City.

Stoughton, Arthur Alexander, Ph.B., ... 1888.
93 Rue de Seine, Paris, France, and 1665 Washington Ave., N. Y. City.

Stoughton, Charles William, C.E., ... 1889.
1665 Washington Avenue, New York City.

Strieby, William, A.M., E.M., ... 1878.
Professor of Metallurgy and Assaying, Colorado College, Colorado Springs, Colo.

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Strout, William Allen, Ph.B., ... 1891.
366 Carlton Avenue, Brooklyn, N. Y.
Suydam, John Richard, Jr., E.M., ... 1879.
14 East Forty-first Street, New York City.

Taylor, Joseph Brown, E.M., ... 1888.
27 Adams St., Columbia Iron Works, and 544 Bedford Ave., Brooklyn, N. Y.
Temple, Seth Justice, Ph.B., ... 1892.
Winona, Minn.
Thomas, Franz Charles, Ph.B., ... 1891.
2438 Indiana Avenue, Chicago, Ill.
Thompson, Milton Strong, Ph.B., ... 1875.
Chemist, Newburyport, Mass.
Thorne, William Lincoln, Ph.B., ... 1890.
Little & O'Connor, 28 W. Twenty-third St., New York City, and
63 High Street, Yonkers, N. Y.
Totten, George Oakley, Jr., Ph.B., A.M. (1892), ... 1891.
62 North Eleventh Street, Newark, N. J.
Toucey, Donald Butler, LL.B., E.M., ... 1882.
261 Broadway, and 743 Madison Avenue, New York City.
Towart, James, C.E., ... 1892.
Box 296, Peekskill, N. Y.
Trowbridge, Samuel Breck Parkman, A.B., Ph.B., ... 1886.
Architect, 7 East Forty-sixth Street, and 33 East Seventeenth Street,
New York City.
Tucker, Allen, Ph.B., ... 1888.
Architect, 65 West Forty-fifth Street, New York City.
Tucker, John Henry, Ph.B., Ph.D., ... 1875.
Address unknown.

Van Boskerck, Robert Ward, E.M., ... 1877.
Artist, 58 West Fifty-seventh Street, New York City.
Van Brunt, Arthur Hoffman, Ph.B., ... 1886.
Architect, 27 West Thirteenth Street, New York City.
VanIngen, Dudley Arthur, Ph.B., ... 1892.
Chemist Fibre Conduit Co., Orangeburg, N. Y., and 135 Henry St., Brooklyn, N. Y.
Van Lennep, David, E.M., ... 1868.
Auburn, Placer County, Cal. Fruit ranch.

Wainwright, Richard Tighe, C.E., ... 1890.
Rye, N. Y.
Wallbridge, Frederick Kidder, E.M., ... 1884.
71 Downing Street, Brooklyn, N. Y.
Walker, Joseph, Jr., C.E., ... 1880.
Mill's Building and 112 East Thirty-seventh Street, New York City.
Wanier, Albert George, Ph.D., ... 1882.
Kruscherville, Staten Island, N. Y.
Ward, Norbert Reillieux, E.M., ... 1882.
Morgan Furn. Co., 1180 Broadway, New York City.
Wardlaw, James Robert, C.E., ... 1876.
25 Chambers Street, New York City.
Warren, Charles Peck, Ph.B., A.M. (1892), ... 1890.
286 Clifton Place, Brooklyn, N. Y.

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Warren, Lloyd, Ph.B., ... 1891.
520 Fifth Avenue, New York City.

Waterbury, Cornelius Reed, C.E., ... 1877.
Lawyer, 250 West Fifty-fifth Street, New York City.

Waters, George Safford, Ph.B., ... 1889.
Architect, Andrews & Waters, 42 W. Forty-third St., N. Y. City.

Webb, Henry Walter, E.M., LL.B., ... 1873.
Third Vice-President, N. Y. C. & H. R. R.R., and 15 West Forty-seventh Street, New York City.

Welsh, Howard Farrington, E.M., ... 1890.
Mingo Mountain Coal and Coke Co., Middlesboro, Ky.

Werner, Henry Clay, Ph.B., ... 1892.
120 East Sixty-fifth St., New York City.

Wetmore, Edwin Atwater, E.M., ... 1875.
Iron Merchant, Marquette, Mich.

Wheatley, Joseph Yendes, C.E., ... 1886.
Pedlar's Run, Monongahela Co., W. Va.

White, Wm. Sherf, E.M., ... 1882
Dept. Docks, Pier A, N. Y. City, and 430 Gold St., Brooklyn, N. Y.

Whitman, Edmund Pineo, E.M., ... 1885.
Puritan Club. Boston, Mass.

Williams, Frederick Harrison, E.M., ... 1874.
Riverside Iron Works, and 34 Virginia Street, Wheeling, W. Va.

Wilson, Clarence Edgar, Ph.B., ... 1896.
Address unknown.

Windecker, Clifton Nichols, C.E., ... 1892.
Brooklyn City Ry. Co. and 33 Sidney Place, Brooklyn, N. Y.

Wood, George E., E.M., Ph.B., ... 1884.
Architect, 63 William St., and 37 West 54th St., N. Y. City.

Wright, Albert Allen, A.M., Ph.B., ... 1875.
Professor of Geology and Natural History, Oberlin College, Oberlin, O.

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LIST No. 4.

Contains the names of Members of the Alumni Association classified territorially by residence. Those not members of the Association are not included by reason of the uncertainty as to address of such persons.

(REVISED TO JULY, 1893.)

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Alabama.—*Birmingham*, C. A. Meissner.

Arizona.—*Globe*, A. L. Walker; *Tombstone*, W. F. Staunton, E. Goodwin.

California.—*Bodie*, T. H. Leggett; *Los Angeles*, W. F. Brugman, L. C. Easton; *Palo Alto*, L. R. Lenox; *San Francisco*, J. L. Lillienthal, D. E. Mellis, E. C. Van Blarcom; *Selby*, E. N. Engelhardt.

Colorado.—*Aspen*, A. F. Bardwell, C. W. Miller; *Colorado Springs*, C. B. Crowell, W. E. Newberry, G. H. Parsons; *Denver*, H. V. F. Furman, M. W. Iles, C. F. Lacombe, G. H. Schroter, T. B. Stearns; *Durango*, E. J. H. Amy; *Glenwood Springs*, W. B. Devereux; *Golden*, M. C. Ihlseng, G. C. Tilden; *Leadville*, L. S. Noble; *Pueblo*, A. S. Dwight, E. C. Eddy, M. B. Holt, F. M. Smith.

Connecticut.—*Bridgeport*, L. H. Norton; *Collinsville*, W. Hill; *Hartford*, A. L. Levy. .

District of Columbia.—*Washington*, E. C. Barnard, Carl Barus, J. S. Cox, Jr., E. M. Douglass, W. T. Griswold, H. Hollerith, F. W. Tower, W. H. Weed, B. Willis, H. M. Wilson.

Florida.—*Barstow*, F. W. Huntington.

Georgia.—*Savannah*, D. B. Falk.

Illinois.—*Carthage*, J. C. Ferris; *Chicago*, E. G. Barratt, P. Le R. Fearn, S. S. Fowler, T. H. Harrington, H. L. Hollis, C. L. Miller, S. B. Peck,, F. B. F. Rhodes, W. H. Van Arsdale, L. Wampold; *South Chicago*, K. E. Eilers.

Idaho.—*Rocky Bar*, L. C. Koch.

Indiana.—*Muncie*, J. R. Marsh.

Indian Territory.—*Hartshorn*, E. Ludlow.

Iowa.—*Davenport*, F. P. Bemis; *Ottumwa*, S. S. Rice.

Kentucky.—*Louisville*, A. J. Lamb.

Louisiana.—*New Orleans*, A. L. Black, G. S. Eastwick.

Maryland.—*Glencoe*, E. A. McCulloh.

Massachusetts.—*Cambridge*, J. A. Noyes; *New Bedford*, N. Hathaway, W. F. Williams; *Salem*, A. Anthon; *Springfield*, L. J. Powers.

Michigan.—*Houghton*, R. M. Edwards, F. McM. Stanton; *Iron Mountain*, J. P. Channing; *Marquette*, R. A. Parker; *Vulcan*, W. Kelly.

Missouri.—*Carthage*, A. O. Ihlseng; *De Soto*, O. M. Munroe; *Springfield*, W. W. Tuttle; *St. Louis*, E. Harris, W. L. Hoyt, H. C. Mannheim, W. B. Potter, A. F. Schneider, E. Starek, A. Thacher, H. A. Wheeler.

Montana.—*Bozeman*, A. M. Ryon; *Butte*, F. Sands, S. D. Gifford; *Deer Lodge*, F. W. Traphagen; *Helena*, W. H. Aldridge, P. A. L. Mannheim, J. R. Parks, C. F. Pearis; *Neihart*, R. M. Raymond; *Smelter*, A. F. Emrich; *Wickes*, H. M. Cole.

Nebraska.—*Omaha*, H. Garlichs.

New Mexico.—*Deming*, T. F. Van Wagenen; *Socorro*, G. B. Lee.

New Jersey.—*Bloomfield*, N. Butler, Jr.; *Dover*, F. A. Canfield; *Englewood*, W. W. Burritt; *High Bridge*, C. Le Boutillier; *Jersey City*, W. F. Downs, R. H. Vondy; *Newark*, H. G. Atha, C. A. Colton, F. W. Kinsey, E. Merz, H. M. Murphy, W. E. Preston, G. C. Stone, F. Vanderpoel, W. Wiener; *New Brunswick*, P. T. Austen, A. H. Chester, W. D. Horne; *Orange*, R. K. Mosely; *Passaic*, E. W. Guiter-

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man; *Perth Amboy*, D. F. Haasi's; *Plainfield*, C. Bullman; *Princeton*, H. B. Cornwall; *Ringwood*, G. M. Miller; *Trenton*, J. H. Janeway.

New York.—*Albany*, F. J. H. Merrill; *Brooklyn*, R. L. Allen, G. H. Behrman, G. Berry, F. Blossom, D. D. Book, G. H. Casamajor, E. D. Church, E. P. Clark, H. R. Connell, J. T. Corcoran, J. A. Deghnée, F. D. Dodge, S. G. Engel, S. A. Goldschmidt, W. A. Herckenrath, J. M. Hewlett, B. C. Hinman, E. D. Hurlburt, W. D. Jones, J. S. Langthorn, F. Lyman, W. M. Meserole, J. Middleton, J. Nesmith, T. S. Perkins, A. J. Provost, C. B. Rowland, G. Rowland, W. W. Share, E. Skinner, G. A. Tibbals, S. G. Tibbals, W. L. Tyler, E. Van Dyck, G. J. Volckening, E. R. Von Nardroff; *Cazenovia*, H. Burden, 2d; *Clinton*, C. H. Smyth; *Ithaca*, S. B. Newberry; *Laurel Hill*, W. C. Ferguson; *Mamaroneck*, F. P. Smith; *Mt. Vernon*, H. D. Conant, R. Mulford; *New Brighton*, A. Hollick; *New Rochelle*, L. P. De Luze; *New York City*, A. Agramonte, S. W. Andrews, L. H. Ansbacher, P. T. Austen, S. W. Balch, W. M. Baldwin, J. H. Banks, G. S. Baxter, A. L. Beebe, W. L. Benedict, F. P. Benjamin, M. Benjamin, W. G. Berry, J. R. Bien, E. M. Blake, O. Bodelsen, W. Boecklin, Jr., R. E. Booræm, R. C. Boyd, S. R. Bradley, N. L. Britton, F. X. Brosnan, F. G. Brown, J. H. B. Browning, W. Bryce, C. R. Buckley, A. L. Burns, E. R. Bush, N. Butler, W. P. Butler, A. Calman, A. C. Canfield, E. P. Casey, J. P. Carson, J. B. Cauldwell, C. F. Chandler, J. A. Church, G. H. Clark, C. E. Colby, S. B. Colt, G. B. Cornell, H. C. Cornwall, J. C. Cox, F. B. Crocker, A. R. Cushman, H. G. Darwin, C. H. Davis, J. W. Davis, J. A. Deghuee, A. F. Delafield, W. A. Dodsworth, C. F. Dolan, H. E. Donnelly, J. S. Douglas, A. W. Dow, S. B. Downes, D. LeR. Dresser, I. W. Drummond, E. L. DuFourcq, E. K. Dunham, W. L. Dusenberry, B. H. Dutcher, W. G. Eberhardt, T. Egleston, A. H. Elliott, W. Elliott, G. E. Fahys, C. F. Ferrer, H. Feuchtwanger, H. Fish, F. W. Floyd, R. G. Foster, A. E. Foyé, J. W. Frank, W. H. Freedman, S. A, Goldschmidt, E. B. Gosling, L. P. Gratacap, J. L. Greenleaf, S. P. Griffin, L. N. Gross, E. Gudeman, E. W. Guiterman, A. W. Hale, R. W. Hall, A. P. Hallock, A W. Hankinson, G. E. Harding, O. B. Hébert, A. M. Heinsheimer, H. H. Hendricks, R. W. Hildreth, W. E. Hildreth, F. N. Holbrook, E. H. Holden, W. A. Hooker, F. F. Hunt, F. R. Hutton, W. C. Illig, O. Jackson, D. M. Jacobs, S. J. Jacobs, A. W. Jenks, B. J. T. Jeup, C. H. Joüet, C. P. Karr, J. F. Kemp, H. S. Kissam, E. C. Koch, J. J. Koen, W. B. Kunhardt, J. Lahey, R. Lahey, B. B. Lawrence, D. G. Leary, G. Leary, E. J. Lederle, A. R. Ledoux, W. P. Little, A. R. Livingston, E. G. Love, L. McI. Luquer, T. T. P. Luquer, G. Lusk, C. F. McKenna, R. A. McKim, J. Maclay, A. S. Mahony, L. F. Massa, R. E. Mayer, C. S. McLoughlin, L. Marie, E. W. Martin, J. H. Merritt, H. H. B. Meyer, E. H. Miller, J. T. Monell, M. R. Montenegro, M. L. Mora, D. E. Moran, L. Morgan, W. F. Morgan, G. W. Morris, R. K. Mosley, A. J. Moses, H. S. Munroe, C. E. Munsell, J. G. Murphy, A. H. Napier, K. Neftel, W. Newbrough, E. L. Newhouse, A. C. Nye, M. J. O'Connor, T. D. O'Connor, E. E. Olcott, E.

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A. Oothout, F. N. Owen, A. McC. Parker, H. C. Parker, C. F. Parraga, Henry Parsons, W. B. Parsons, C. Q. Payne, C. E. Pellew, J. P. Pennington, W. Pistor, L. Pitkin, H. H. Porter, Jr., A. S. Post, A. V. Z. Post, J. C. F. Randolph, J. F. Randolph, R. Raynor, G. F. Reckhardt, S. A. Reed, B. F. Rees, J. K. Rees, G. Renault, J. M. Rich, P. de P. Ricketts, T. W. Ridsdale, H. Ries, F. Roeser, O. L. Rogers, C. M. Rolker, O. N. Rood, R. G. Rood, A. Rosenthal, P. Rupp, F. Ruttman, E. E. Sage, F. A. Schermerhorn, W. J. Schiefflein, C. Schumann, J. G. Seligman, H. T. Shriver, F. M. Simonds, A. Smith, L. Smith, W. A. Smith, T. E. Snook, G. C. Southard, A. N. Spooner, J. A. Staunton, J. Struthers, W. H. Stuart, G. A. Suter, H. C. Thompson, W. H. Titus, G. R. Tuska, J. H. Van Amringe, A. H. Van Sinderin, E. Van Volkenburgh, H. T. Vulte, J. H. Wainwright, E. E. Waller, W. R. Ware, W. H. Weeks, H. McM. Welsh, J. S. C. Wells, P. O. Wels, R. D. White, H. P. Whitlock, F. Wiechmann, J. T. Williams, E. P. Windolph, C. A. Wittmack, I. H. Woolson, E. L. Young; *Niagara Falls*, E. Z. Burns, S. Freedman, W. S. Humbert; *Northport*, W. H. Ingersoll; *Ontario*, E. M. Parrot; *Poughkeepsie*, A. E. Tower; *Rochester*, T. Nolan; *Sing Sing*, W. S. Page; *Skaneateles*, F. M. Thomas; *Spuyten Duyvil*, E. M. Johnson, G. H. Johnson, I. B. Johnson, L. B. Longacre; *Syracuse*, H. B. Bellinger; *Tarrytown*, F. N. Holbrook; *Ticonderoga*, F. C. Hooper; *Tuxedo Park*, E. N. Van Cortlandt, *Utica*, G. W. Williams; *White Plains*, R. E. Slade; *Whitestone*, W. J. Wallace, D. W. Ward; *Yonkers*, S. W. Balch.

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CONSTITUTION

OF THE

ASSOCIATION OF THE ALUMNI

OF THE

SCHOOL OF MINES OF COLUMBIA COLLEGE

INCORPORATED MAY, 1886.

ARTICLE I.

NAME.

THE name of this Association is "The Association of the Alumni of the School of Mines of Columbia College."

ARTICLE II.

OBJECT.

The object of this Association is to promote the professional welfare of its members, and to strengthen the bonds of professional and social fellowship among the Alumni of the School of Mines.

ARTICLE III.

MEMBERS.

SECTION 1. The membership in this Association shall be: I. Active. II. Associate. III. Honorary.

SEC. 2. All graduates of the School of Mines are eligible to active membership in this Association.

SEC. 3. Persons who have completed any of the special or graduate courses of the School of Mines are eligible to associate membership in this Association.

SEC. 4. Persons eminent in science who are or have been connected with the School of Mines are eligible to honorary membership in this Association.

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SEC. 5. All members shall be elected by the Association upon proposal by the Board of Managers.

SEC. 6. Honorary and associate members shall have all the privileges of active members, except those of voting and holding office.

ARTICLE IV.

DUES.

SEC. 1. The annual dues of active and associate members of this Association shall be three dollars, payable in advance on the first day of October in each year. Honorary members shall not be required to pay dues.

SEC. 2. Any member not in arrears may become a life member, and be relieved from further payment of annual dues by the payment, at any one time, of fifty dollars.

SEC. 3. Members one year in arrears may, after due notification, be dropped from the roll, by vote of the Board of Managers, and shall then forfeit their rights and privileges in the Association until all arrears are paid, or until reinstated by the Board.

SEC. 4. Only those members not in arrears shall be entitled to vote or hold office.

ARTICLE V.

OFFICERS AND MANAGERS.

SEC. 1. The officers of the Association shall be a President, a Vice-President, a Treasurer, and a Secretary. These officers and eight managers, to be elected as hereinafter provided, shall constitute the Board of Managers.

SEC. 2. The President, Vice-President, Treasurer and Secretary shall hold office for one year, and are eligible for re-election. The Managers shall hold office for two years, and are not eligible for re-election until one year after the expiration of their terms.

ARTICLE VI.

ELECTION OF OFFICERS AND MANAGERS.

SEC. 1. Before the last day of June of each year the President shall appoint a committee of five active members to nominate for election by the Association for the ensuing year a President, a Vice-President, a Treasurer, a Secretary and four Managers.

SEC. 2. The Nominating Committee must send in the nominations to the Secretary not later than October 15th of each year,

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and such nominations shall be distributed at once to the active members in the form of letter ballots, which must be signed and forwarded to the Secretary, and opened and counted by tellers at the annual meeting of the Association.

SEC. 3. The officers and managers must be residents of New York city or vicinity, and the four managers shall be selected, one from each of the four groups into which the Board of Managers shall, at its first meeting in each year, divide in chronological order the classes which have graduated from the School of Mines.

ARTICLE VII.

THE BOARD OF MANAGERS.

SEC. 1. The Board of Managers shall have the management of the affairs, funds, and property of the Association, and it shall be the duty of the Board to see that the purposes of the Association are carried out according to its Constitution and By-Laws.

SEC. 2. The Board of Managers shall hold at least four regular meetings during each year, namely, in the months of January, May, October, and December. Other meetings shall be called by the President as may be required.

SEC. 3. The Board shall have power to fill any vacancy in its body by the election of an active member of the Association from the group in which such vacancy occurs.

SEC. 4. A quorum shall consist of a majority of the whole Board.

ARTICLE VIII.

PRESIDENT.

It shall be the duty of the President to call and preside at all meetings of the Board of Managers and of the Association; to appoint such standing and other committees of the Association as may be found necessary or convenient for the conduct of its work, and to perform such other duties as may devolve upon him by virtue of his office.

ARTICLE IX.

TREASURER.

It shall be the duty of the Treasurer to collect and have custody of all moneys and pay all bills of the Association, but no indebtedness shall be incurred unless approved by the Board of

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Managers. No bill shall be paid unless previously endorsed by the Secretary. The Treasurer shall present to the Board of Managers a written report upon the financial condition of the Association at the annual meeting in December. His accounts shall be audited by a committee of the Association appointed at the annual meeting.

ARTICLE X.

SECRETARY.

It shall be the duty of the Secretary to issue notices for all meetings of the Board of Managers and of the Association, to keep minutes of all meetings, to record the names, addresses, and professional occupations of the members, and to perform such other duties as may be assigned to him by the Board of Managers.

ARTICLE XI.

MEETINGS.

SEC. 1. The annual meeting of the Association shall be held in the last week of December in each year, unless otherwise ordered by the Board of Managers.

SEC. 2. Regular meetings of the Association for social intercourse, or for the discussion of subjects of general or of professional interest, shall be held in the city of New York at such time and place as may be directed by the Board of Managers.

SEC. 3. Upon the written request of not less than ten active members, the President shall call a special meeting of the Association, which request, as also the notice of any special meeting, shall state the object for which the meeting is called.

SEC. 4. A quorum shall consist of thirty active members of the Association.

ARTICLE XII.

SUSPENSION OR EXPULSION.

Any member of the Association may be suspended or expelled for misconduct in his relations to this Association or in his profession on proof thereof in such manner as may be prescribed hereafter by By-laws.

ARTICLE XIII.

All interest in the property of the Association of persons resigning or otherwise ceasing to be members shall vest in the Association.

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ARTICLE XIV.

AMENDMENTS.

Any amendment to the Constitution must first be submitted in writing to the Board of Managers, and must be approved by a vote of two-thirds of the whole Board before presentation to the Association. Due notice of any proposed amendment shall be sent by the Board of Managers to every active member of the Association at least one month previous to the meeting at which such amendment is to be voted upon. A three-fourths vote of the members voting, in person or by letter ballot, shall be necessary for the adoption of such proposed amendment.

BY-LAWS.

I. Unless otherwise directed the Order of Business at any meeting of the Association and its Board of Managers shall be as follows:

1. Reading of minutes of preceding meetings and action thereupon.
2. Report of the Board of Managers.
3. Reports of officers.
4. Reports of standing committees.
5. Reports of special committees.
6. Elections and announcement of elections.
7. Unfinished business.
8. New business.
9. Appointment of committees.
10. Adjournment.

II. The absence of any member of the Board of Managers from two consecutive meetings of the same, of which he shall have been regularly notified, shall be considered as a resignation on the part of such member, unless the Board shall excuse such absence. The vacancy thus created shall be filled as provided for in the Constitution.

III. The Standing Committees of the Board of Managers shall be as follows:

1. On School of Mines Quarterly.
2. On Badges.
3. On Meetings of the Association.
4. Of Conference with the Columbia College Alumni Association, and such other Committees as may be necessary.

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All such committees shall, at the expiration of their terms of office, present written reports to the Board of Managers.

IV. The official organ of this Association shall be the SCHOOL OF MINES' QUARTERLY, which will be furnished to all active and associate members.

V. The Standing Committee on Meetings shall arrange for regular meetings of the Association in October and March of each year unless otherwise ordered by the Board of Managers.

VI. These By-Laws may be amended at any regular meeting of the Association, but only by a vote of two-thirds of those present, and provided that ten days' notice in writing of the proposed amendment shall have been given to the Board of Managers, and also that notice of the same shall have been given by the Secretary in the call for the meeting.

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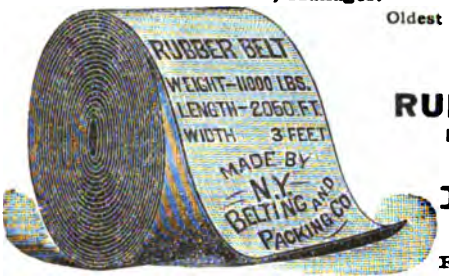

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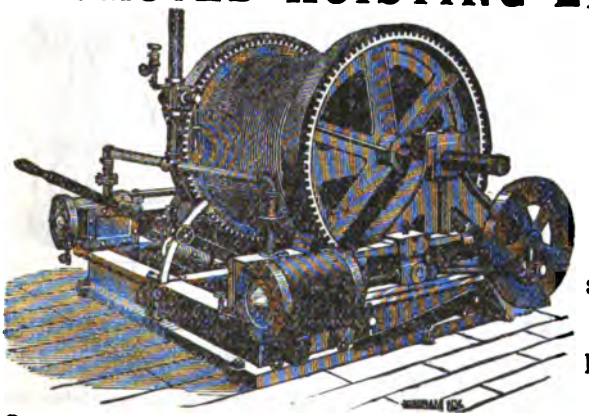

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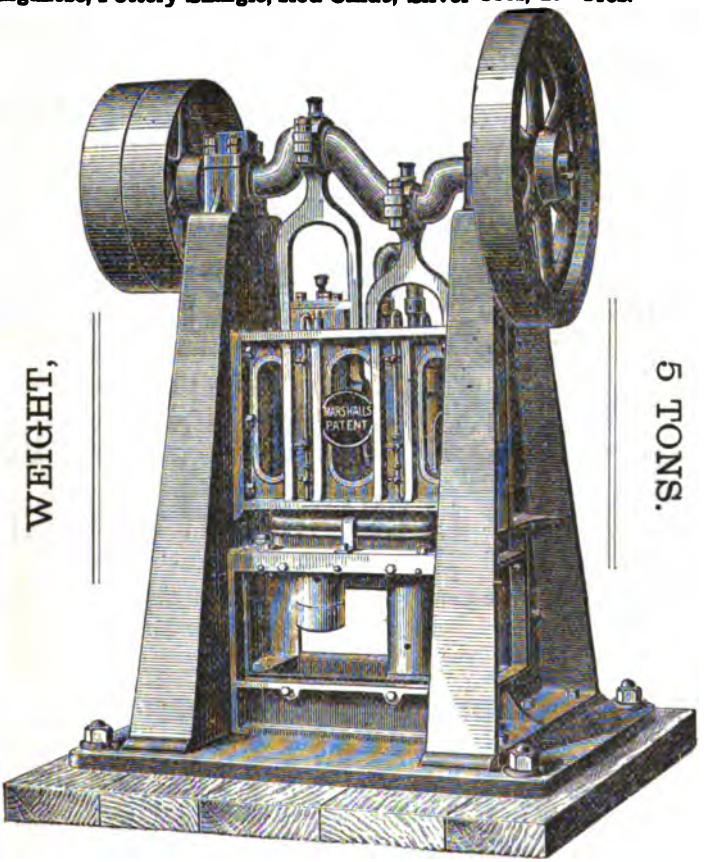

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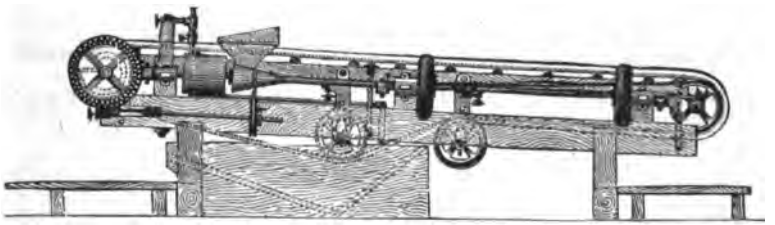

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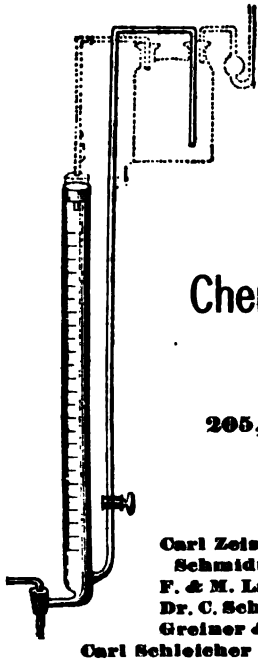

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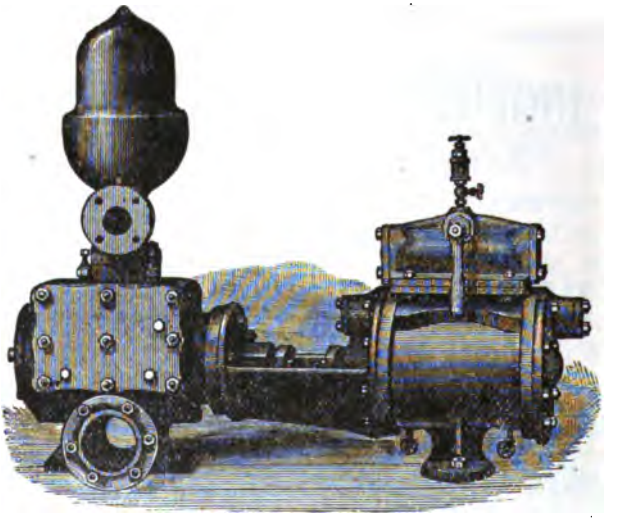

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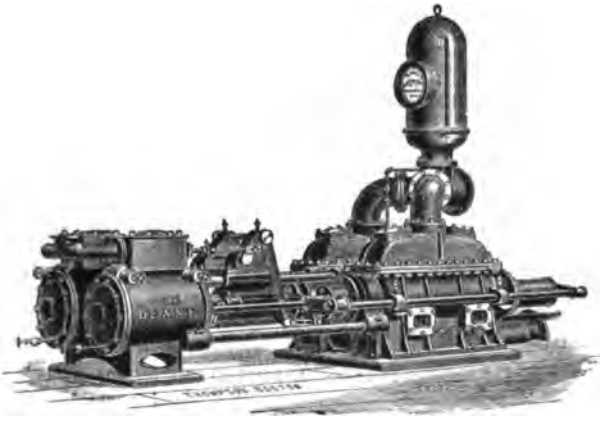

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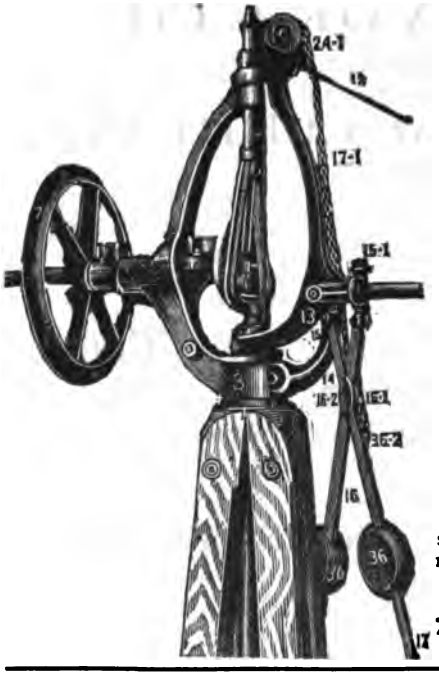

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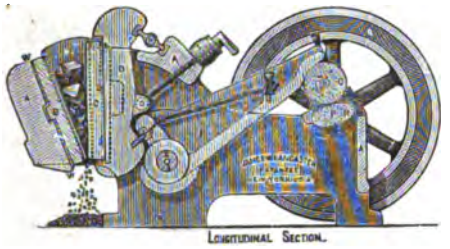

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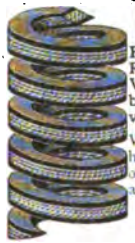

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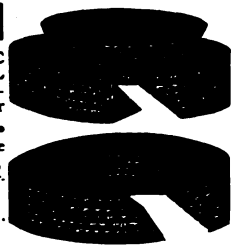

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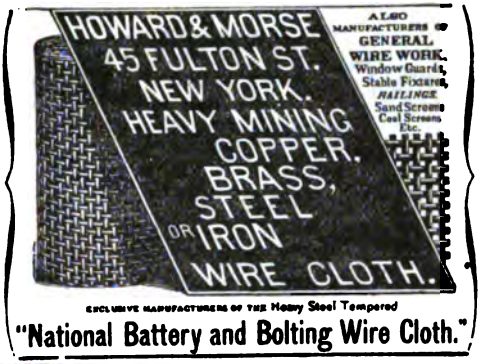

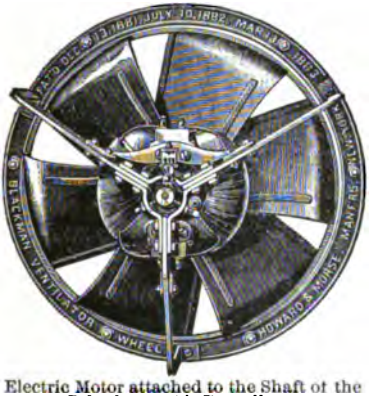

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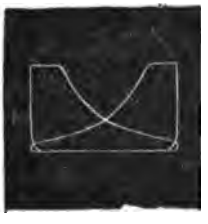

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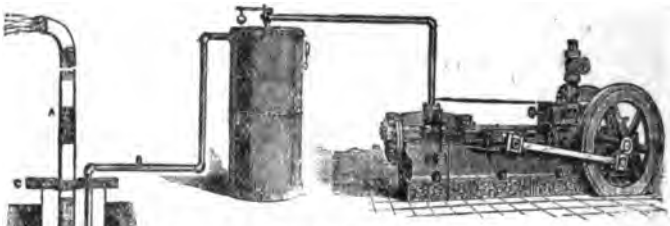

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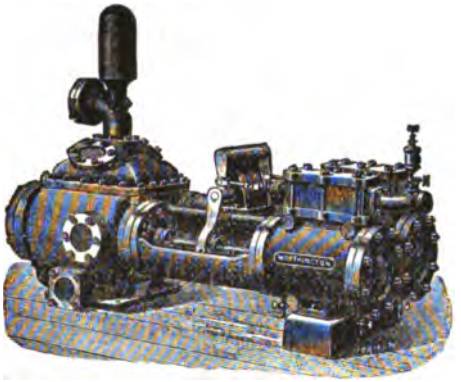

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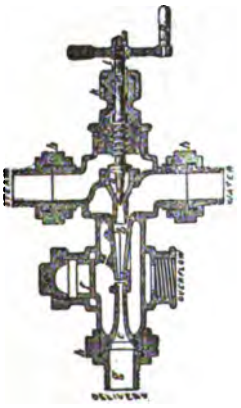

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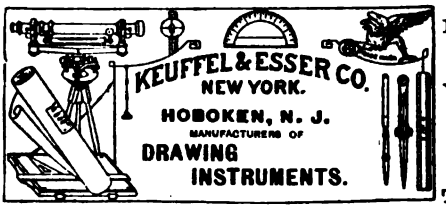

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